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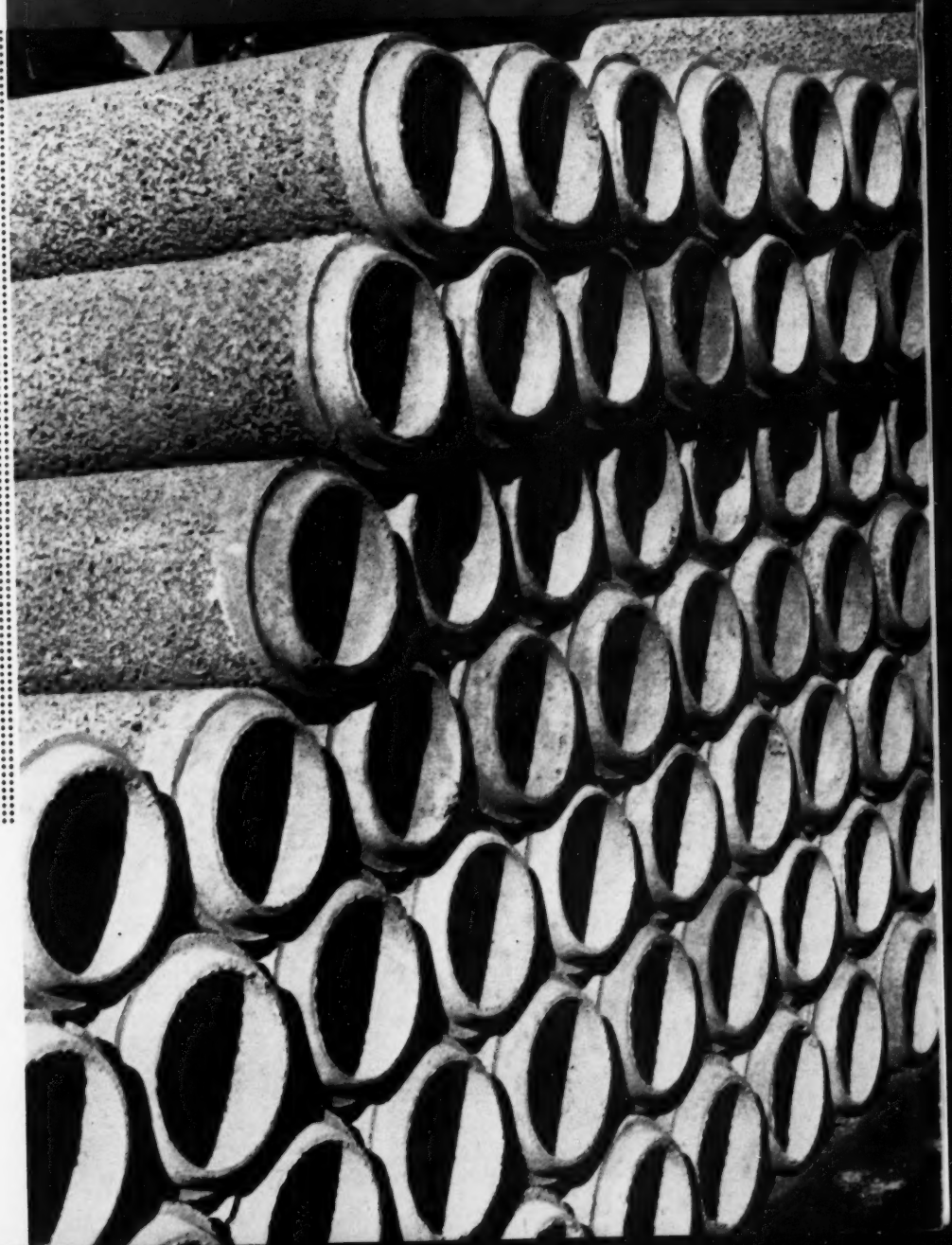

MARCH, 1954

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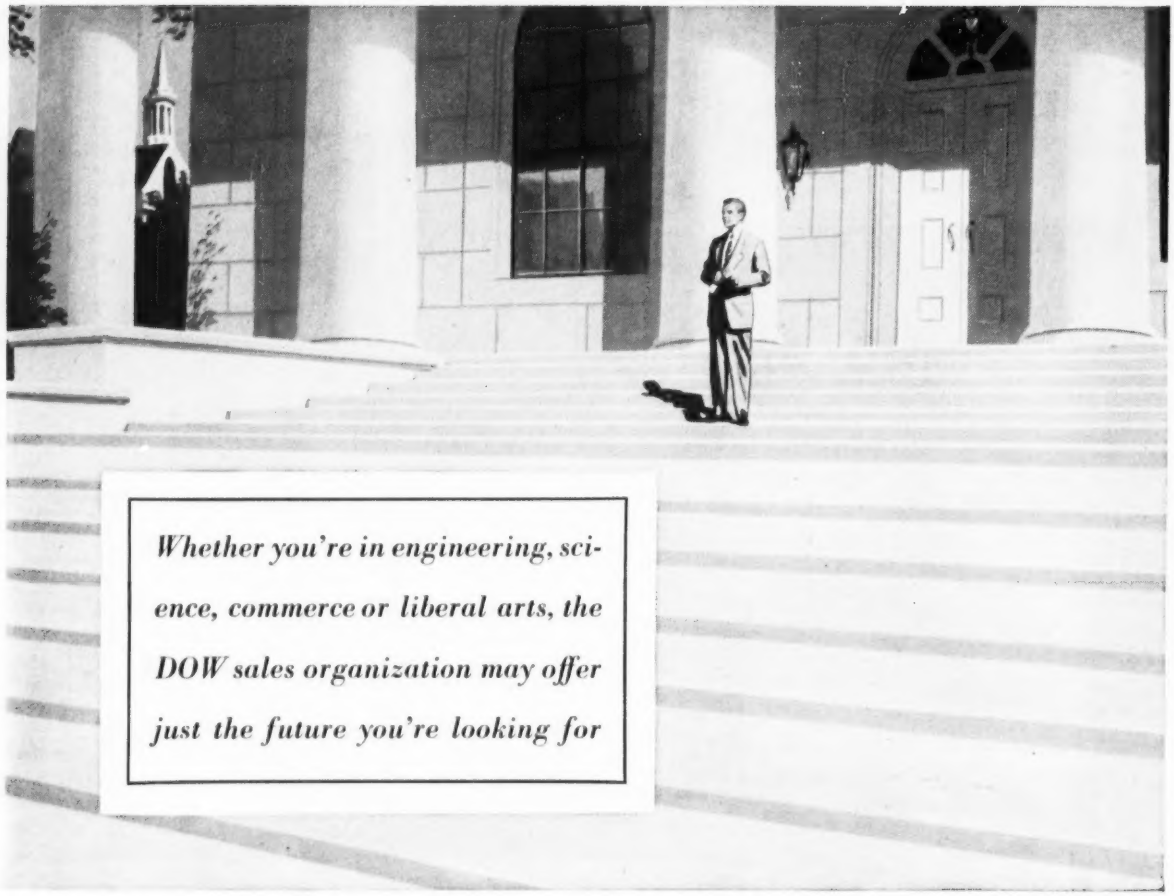
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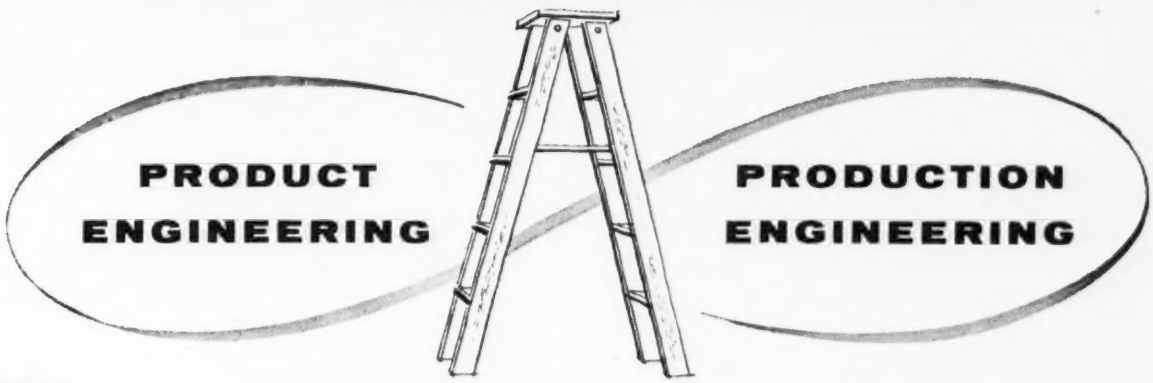


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**Section of 130-year-old cast iron water main still in service in Philadelphia, Pa.**

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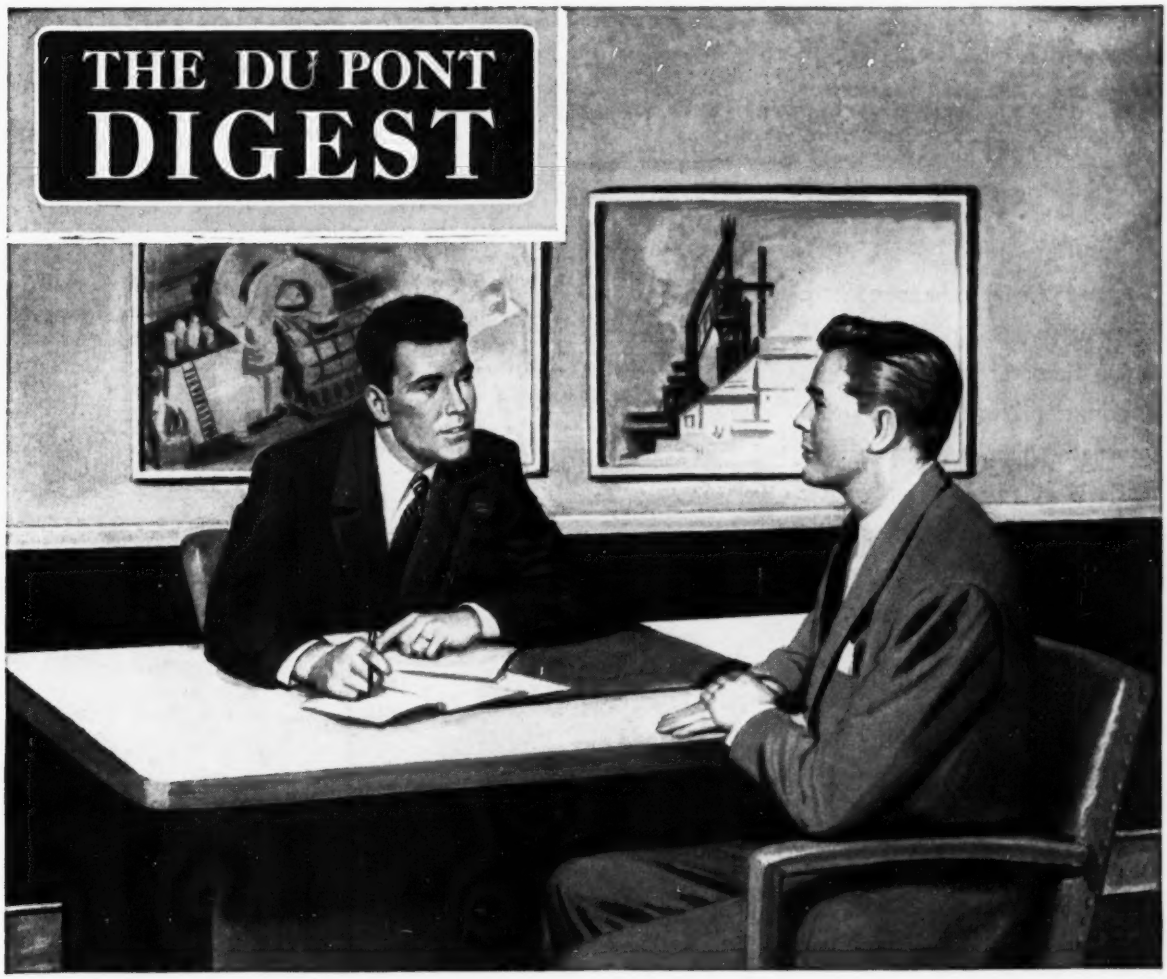


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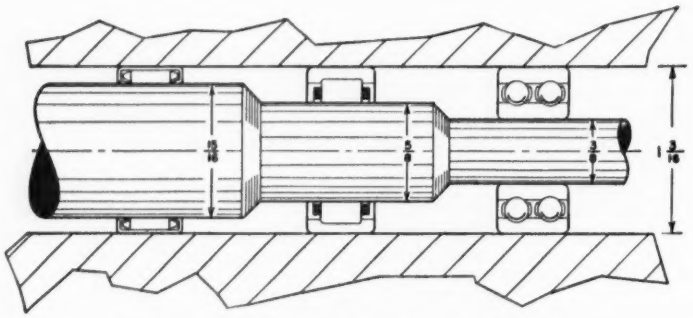

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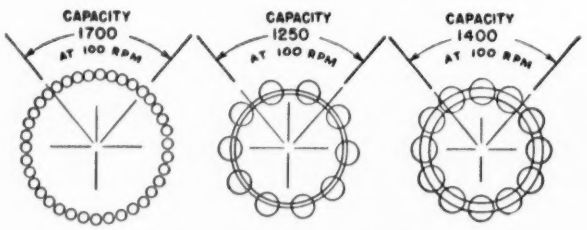


**2.** *Shows the greater number of lines of contact in the load zone of a Needle Bearing compared with a ball or roller bearing.*

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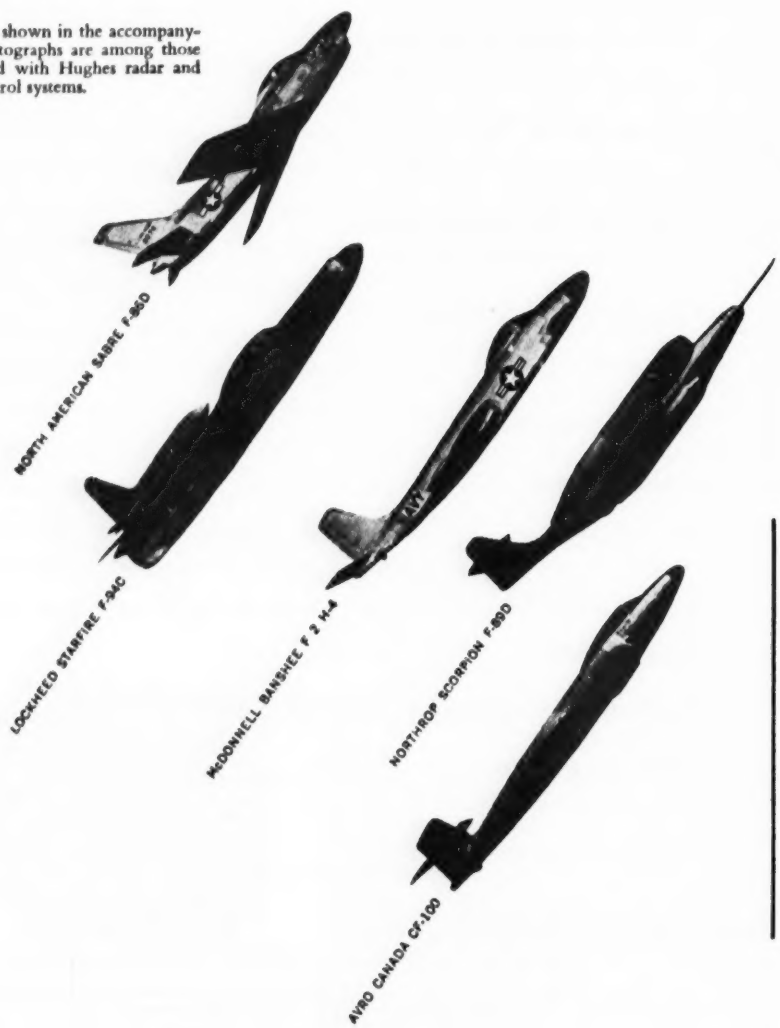
Aircraft shown in the accompanying photographs are among those equipped with Hughes radar and fire control systems.

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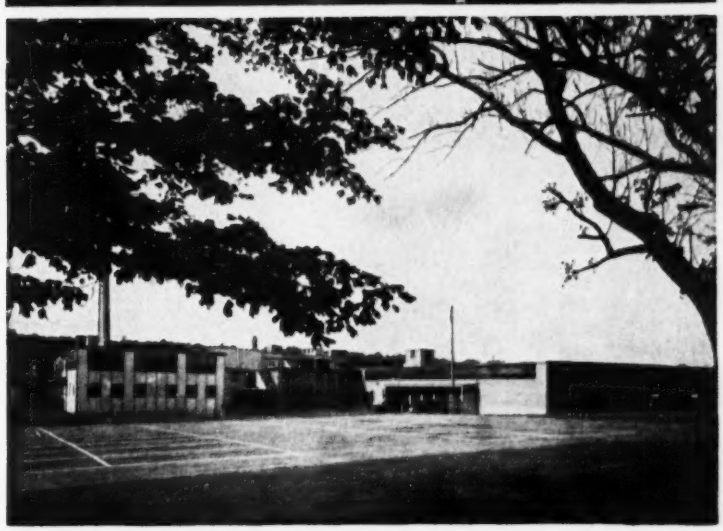
# Height of the **fire**

# at **two** chemical plants



One plant is a seething inferno. Several persons were injured in this mid-western chemical plant fire, which resulted in a $600.000 loss.

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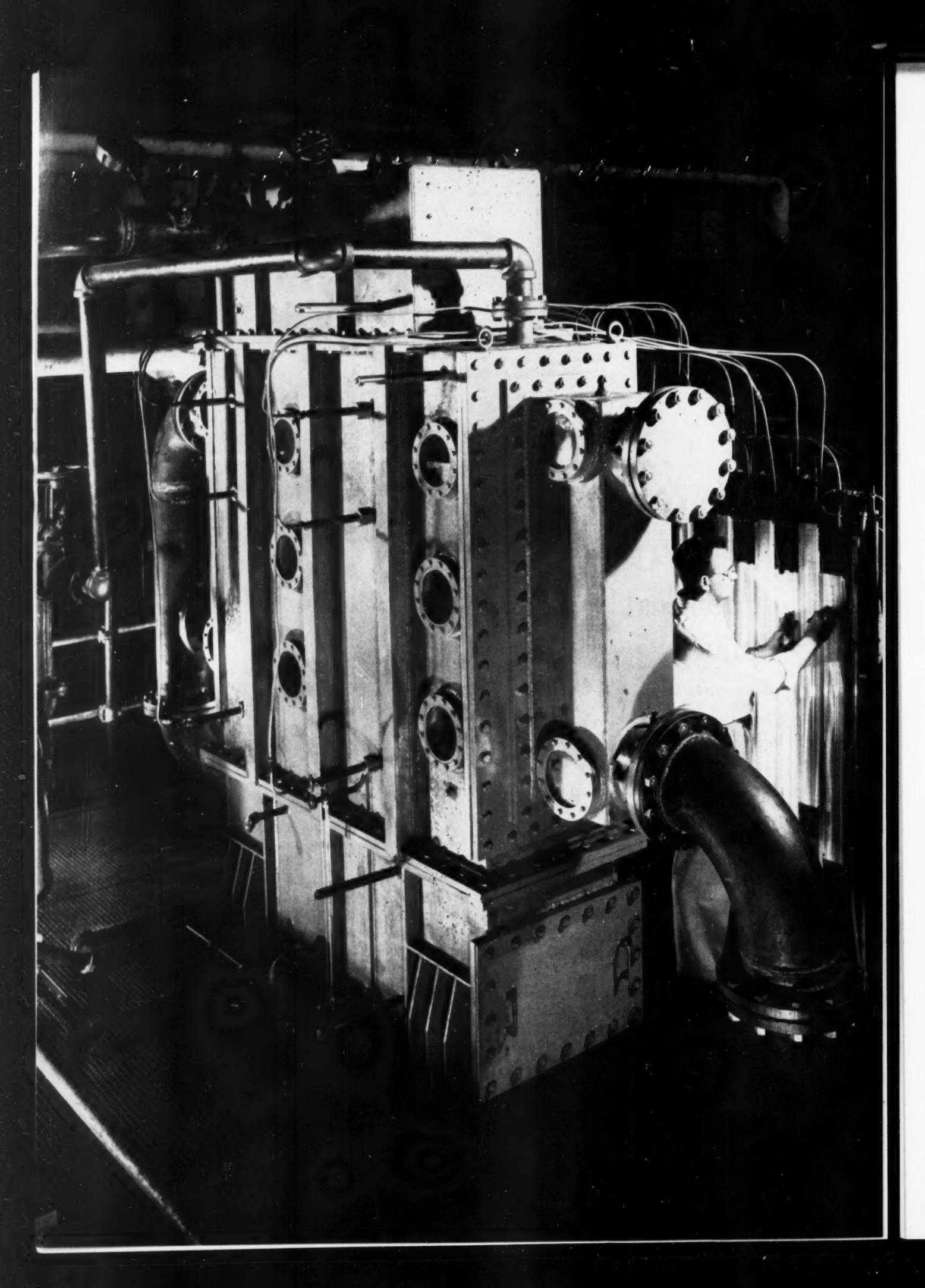


# The Ether-drift Experment

by ARTHUR H. VAUGHAN EP '57

The historic series of optical measurements known as the "Michelson-Morley Ether-drift Experiment," which were performed in 1887 by the late Professors Albert A. Michelson of the University of Chicago and Edward W. Morley of Western Reserve University, Cleveland, have often been discussed in connection with modern versions of electromagnetic theory. This experiment, broadly speaking, may be considered to have given the first clear-cut evidence leading to the inception of some of the revolutionary present-day notions of light and the structure of matter.

The purpose of the ether-drift measurements was to detect a relative motion of the Earth within the medium which was expectedly responsible for light transmission, the "luminiferous ether." But Michelson and Morley were reputedly unable to find the effect of such Earth-ether motion. Subsequently it was concluded from the no-motion answer yielded by the experiment that there really was no ether, and that previous theories of light based upon the assumption of an ether must be discarded. All other experiments of this nature have yielded substantially this same result, so that today there is absolutely no doubt that the conclusion is the correct one.

But in spite of the seeming well-settledness of the question there remain a number of problems pertaining to the ether-drift experiments which are still of interest. These problems involve explaining the fact that in the indicated results of the experiments there was a small but apparently systematic deviation from the *absolute zero indication* of Earth-ether motion which modern theory ought to have yielded. This deviation has very often been neglected because of the widely accepted opinion that the results insofar as they were not quite zero were erroneous. Surprisingly, many statements have been published to the effect that "no trace of an ether-drift was ever found," or that "all experiments showed an exactly null ether-drift." The indicated drift, however, was never found to be in fact exactly null, and the small anomalous result has been unexplained for over 67 years.

**Experimental surface-type steam condenser.**

*—Allis Chalmers Mfg. Co.*

### Experiment Repeated

Because the exact null drift is one of the most fundamental postulates alluded to by those who sought to develop modern physics, and because such a result had never actually been obtained, the Michelson-Morley experiment was repeated in a far more complete and elaborate form by the late Professor Dayton C. Miller of the Case School of Applied Science (now the Case Institute of Technology) during the years 1921 to 1927. Miller's work is not so well known as Michelson's. It is a significant fact, however, that while Michelson performed his experiment only twice, and for very brief periods of time each, Miller continued his measurements throughout the year and at all times of day, a unique contribution to the subject. He thus obtained enough data to allow a complete analysis of the cosmic motion of the Earth. The results of the analysis were systematic in that they showed a fairly evident motion of the Earth toward an apex in the vicinity of the southern celestial pole. Miller stated that his results and Michelson's were agreeable; where Michelson found an apparent drift only 1/40 of that predicted by the ether theory, Miller found effects varying from 1/17 to 1/90 of the expected amount.

All this pointed strongly to the conclusion, which Miller unfortunately adopted, that the observed effect was due to a real ether-drift.

Although the subject is by no means significant theoretically, at the present time, it has been a question just how large a margin of error is present in a difficult experiment of this kind, and what influence external affairs might have had upon the results.

This very brief review of the problem is devoted to describing in a little detail Professor Miller's repetition of the Michelson-Morley experiment.

In Newton's time there were two conflicting ideas developed to explain the transmission of light: Newton's own "corpuscular theory," and the ether theory, which was first clearly formulated slightly later by Christian Huygens (1678). Both theories required the "invention" of either particles or substances. For many reasons, including the fact that diffraction of light could be interpreted in terms of waves but not particles, and the philosophical preference for assuming the presence of just one substance rather than a large number of different kinds of particles, the corpuscular theory was abandoned some one hundred years later, by most physicists, in favor of ether-waves.

Today, of course, corpuscular

theory dominates scientific thinking. Although certain phenomena have not been completely explained by the particle theory, the concept of an ether has been virtually abandoned.

**The Ether Theory**

The ether scheme supposed that there be a medium permeating all space, including that occupied by material bodies, "at rest in absolute space," offering no obstruction to the motion of matter, yet having sufficiently high elasticity and low enough density to permit the elastic propagation of wave motion at 300,000 kilometers per second. Ether must furthermore be a solid, because by means of polarization experiments (and other demonstrations) light "waves" are shown to be transverse; transverse waves occur only in solids, or in jellies.

The ether concept grew to somewhat ponderous size and the list of highly unnatural ether-properties became increasingly troublesome. Considering the serious and fundamental character of the subject, physicists became interested in finding out whether or not there really was an ether. The mathematical theory of elasticity was at that time not sufficiently developed to allow much more than an empirical investigation of the properties of ether. The work of Fresnel (1822) is most noted, and although there is no longer any application to the original subject ether, his contributions remain as an important background of modern elasticity theory.

The need for a definite test of the ether theory led James Clerk Maxwell in 1878 to propose the ether-drift experiment. On the basis of the ether theory, *the velocity of light with respect to the ether should be a constant.* Hence if one moves through the ether, the apparent velocity of light should be a function of the speed and direction of the observer, and should be the result, simply, of addition of velocities. This is what is often called an "optical dissymmetry of space," dependent upon the motion of the observer.

**Measuring the Velocity of Light**

The only practical method of measuring the velocity of light is to allow a beam to traverse a path AB and be reflected by a mirror at B back to A. The variation in transmission time would then be a measure of the difference in velocity, if there were an ether-drift. Written below is a derivation of this effect, or time lag:

The total time required to go and return along a path *parallel* to the motion of the earth is

$$T_1 = \frac{L}{c+v} + \frac{L}{c-v} = \frac{2Lc}{c^2-v^2}$$

where c is the velocity of light, v is the velocity of the earth, and L is the distance between source S and mirror M. After expanding into series and neglecting terms of power higher than second (since v is considerably smaller than c),

$$T_1 = \frac{2L}{c}\left(1 + \frac{v^2}{c^2}\right)$$

The quantity $\frac{2L}{c}$ is the transit time in stationary ether.

When the path is at *right angles* to the Earth-ether motion, the time of transit is

$$T_2 = \frac{2L}{(c^2-v^2)^{1/2}}$$

considering right triangles. After expanding again and neglecting terms, the time

$$T_2 = \frac{2L}{c}\left(1 + \frac{1}{2}\frac{v^2}{c^2}\right)$$

The difference in these times is

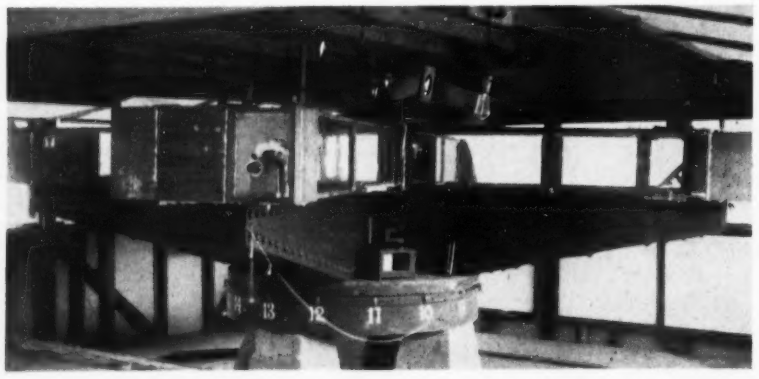
$$T_1 - T_2 = \frac{1}{2}\left(\frac{2L}{c}\right)\frac{v^2}{c^2}$$

Thus the "second order effect," as Maxwell called it, is shown to be proportional to the square of the ratio of the velocity of the earth to the velocity of light, and turns out to be of the order of one one-hundred-millionth part of the total time of transit. It would, according to Maxwell, "therefore be quite insensible." Unknown to Maxwell, Michelson had recently announced the invention of his remarkable instrument, the interferometer, while a student at the University of Berlin. Michelson accepted Maxwell's challenge, and immediately adapted the instrument to a form capable of measuring an ether-drift. Miller employed a similar kind of interferometer, shown in Fig 1.

**The Interferometer**

Measurement of ether-drift is based upon the fact that changes in the patterns of interference of light, produced by changes either in actual length of path or in optical properties or velocity of the light, will be observable, the measurements being made in terms of wavelengths. The optical parts of Miller's interferometer are carried by two rigid structural steel girders, each about fourteen feet long, intersecting to form a cross. Such a construction proved to be quite stable. A weight of 282 grams (.622 lb.) placed on the end of one arm produced a change in the optical system equivalent to about one wavelength of light. Miller showed that by keeping the instrument in fair balance no objectionable deflection would occur. The arms are allowed to rotate on a vertical axis by means of a circular wooden float (Fig. 2.) attached at the center to the underside of the cross. The en-

***Fig.* 1. Interferometer used to detect an apparent change in the velocity of light because of the existence of an ether. An absolute null result would discount the ether theory.** —*Case Institute of Technology*



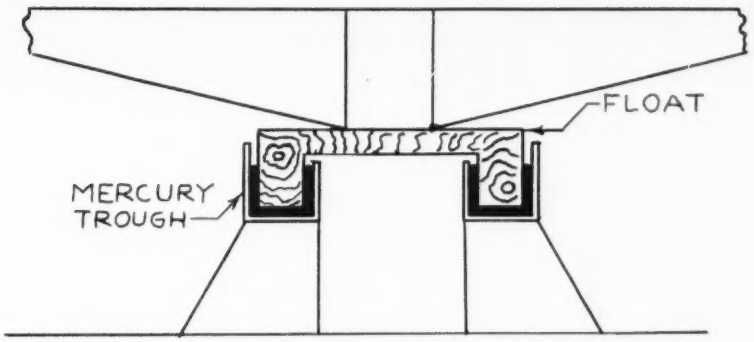



*Fig.* 2. **Diagram showing the construction of the interferometer to permit almost frictionless rotation in mercury trough.**

tire apparatus was floated in a ring-shaped cast iron trough of mercury at the base, and held centered by a loose fitting vertical pin. About 275 kilograms of mercury were required to float the 1200 kilogram (2650 lb.) apparatus. The action obtained in this way was smooth running and nearly frictionless.

Fig. 3 is a diagram of the optical paths in the interferometer. Four optically flat mirrors, "flats," are located at the ends of each arm and are adjusted by means of micrometer screws. M is a half-silvered flat. Light from source S is partially reflected and partially transmitted by M. The first part is directed to flat $B_1$, and subsequently follows the path $B_1$, $B_1'$, $B_2$, $B_2'$, $B_3$, $B_3'$, $B_4$, $B_4'$, $B_4$, $B_3'$ and so on to $B_1$ from which approximately half is passed through M to the observing telescope T. The remainder of the light which was originally transmitted by M follows an identical to and fro path in arm $AA_1$, and also enters the telescope after being reflected by M. Adjustments had to be made to bring the two multiple paths into approximate equality, not differing by more than two wavelengths or about $10^{-4}$ centimeters.

Because the paths are not precisely equal, the two components of light entering the telescope will be slightly "out of phase" with each other, causing a pattern of nodes and loops to form. This pattern of interference, called fringing, will seem to consist of vertical alternated dark and light stripes superimposed on the surface of the most distant mirror (optically) from the scope. If this flat is exactly perpendicular to the rays of incident light, the interference will fall in laminated planes parallel to the flat, and since the observer's line of sight is along the rays of light, any existing fringes would be invisible. The trick consists in rotating the flat so that it is not quite perpendicular, thereby getting a shaved-off, wedge, view of the pattern. What is now seen is the ends of the stacked interference planes, apparent as stripes. On the supporting frame of the most distant mirror Miller attached a pointer projecting into the field of view by which the position of the center stripe could be determined. Fig. 4 is a sketch of the interference fringes as seen in the interferometer.

The light paths are so arranged that a change in velocity across one of the multiple paths (AA′ or BB′) will produce a change of phase of the two trains falling upon the mirrors whose images are seen simultaneously in observing the telescope, and the change will be evident as a lateral shift of the fringes. Changing the length of path in one of the arms has of course the same effect. The shift would be one fringe-width when the change of path is equal to one wave length of the light. The result of ether-drift is (or would be) to cause such a dissymmetry, which would be detectable upon rotating the interferometer and constructing graphs of the fringe positions. The mathematical reduction of such data is actually a complicated process, largely worked out by Dr. J. J. Nassau of the Department of Astronomy at Case.

It can be shown that the *then expected* ether-drift would be detectable and easily measurable.

The interferomter, set into motion by an initial push, would continue to rotate at the rate of about one turn in fifty seconds for close to an hour and a half, during which time an observer following the eyepiece around recorded the fringe positions. Dr. Miller commented in his report that "very few, if any scientific experiments require the taking of so many continuous observations of such extreme difficulty . . . . Half the time, perhaps, the observations are interrupted before they become numerous to be useful because of . . . temperature variations (or) Earth or aerial vibrations."

Over a period of six or seven years Miller accumulated several volumes, consisting of millions of fringe readings. Most of these were taken at a site near the 100 inch (Hooker) telescope on Mt. Wilson. Previous to 1925 no attempt was made to analyze the apex of indicated motion of the earth. The

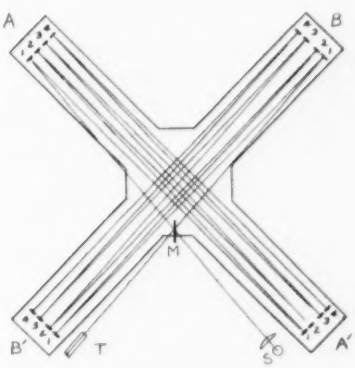



*Fig.* 3. **Schematic view of the interferometer, showing the optical paths.**

experiment was applied, stated Miller, to test the effects of certain possible external influences which may have been the cause of earlier positive drift readings. These were: magnetostriction, gravitational deformation of the frame of the interferometer, radiant heat and extraneous light, and the so-called Lorentz - Fitzgerald hypothesis which is a deduction from the electron theory of matter showing that a body in motion (such as the inter-

fermometer) experiences a contraction in the direction of its motion exactly counter-acting the ether drift effect. (The purpose of this last test was to find whether the contraction depended upon the composition of the body, but no dependance was noted, in accordance with the L-F hypothesis.)

To carry out the other tests Miller constructed a new instrument of concrete and nonmagnetic materials so as to compare nonmagnetic interferometer results with those obtained from the steel one. No difference was found, thereby eliminating the possibility of magnetostriction being influential.

Tests were made at various times to determine the rigidity of the steel cross. The arms were loaded in various ways with weights, rotation was reversed, and tried at several speeds. No essential variations could be observed either in period or magnitude of the fringe shifts obtained in this way.

The answers to the possibilities of disturbance was repeatedly a "no".

**Present Status of the Topic**

A broad summary of the problem is this: The ether theory required that the velocity of light measured on the Earth be variable with direction, due to the motion of the Earth through the ether, a situation analogous to the velocity of sound in air as measured from a moving vehicle. This light-velocity-variation (if it existed) could be detected by an interferometer mounted in the way described.

Michelson and Morley in 1887 found only a small fraction of the magnitude of variation expected. His work was not conclusive because of the lack of sufficient quantity of observations, and because it was not in agreement with either the ether theory or the later electromagnetic theory.

Miller's work agrees with Michelson's in giving essentially a null result. But the fact remains that his results display such systematic fluctuations (with the rotational and orbital motion of the earth) as would occur if there were in fact an ether-drift. These fluctuations are unexplained.

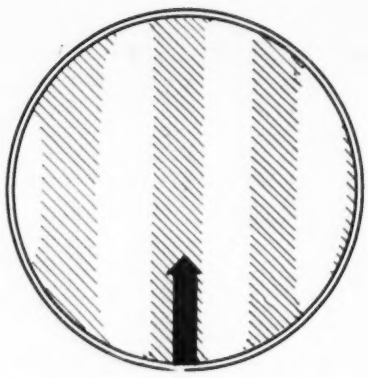


*Fig.* 4. **Fringes as they appear in the interferometer telescope. The fixed pointer is a reference from which the fringe shifting can be detected.**

Experimental work of other kinds has in recent times given almost undoubtable evidence in favor of modern theory, so that an ether (and hence an ether-drift) cannot possibly be present. From today's viewpoint, an ether-drift experiment *must* yield an exact null result.

Since the results of these experiments *never have been null,* there must have been something wrong with them. This is the opinion adopted by most physicists concerned with the problem.

No modifications of electromagnetic theory have been forthcoming capable of explaining the questionable result. An attempt was made by J. L. Synge to develop a theory considering the acceleration of the interferometer with the motion of the earth. It appeared at the start that there would be some agreement of Synge's theory with Miller's results; but the results Synge predicted would have been observed by an interferometer mounted in a different way from Miller's. Synge's experiment was carried out by R. W. Dutchburn, and is reported in *Nature*, 170, 705 (1953). His result disagreed entirely with the explanation of Miller's results offered by Synge.

It is certain that no erroneous procedures were used by Dr. Miller in performing the experiment. It can nevertheless be said that the detailed reduction of his data into velocity and direction-of-motion components was "squeezing the last available drop" of information from what he had obtained. A study of Miller's work is now in progress at Case in Cleveland. This amounts to a "statiscal analysis" of the results, for there is no need to repeat the experiment. Although no report had been published as yet, Dr. R. S. Shankland, Chairman of the Department of Physics at Case, states his opinion that it is probable that the analysis will show Miller's results to be "merely the statistical fluctuations of the readings in a very difficult experiment". Dr. Shankland believes it at least a possibility that a part of D. C. Miller's and others' small non-zero result was due to temperature variations.

While Michelson's results were non-conclusive, it is fairly evident that the meticulous nature of Miller's experimental work should have led to the correct results. If Miller's results can be shown to be within the limits of measuring error, it is then safe to say that he has produced experimental proof of the absence of an ether-drift. Theoretical physicists have been satisfied, since the original 1887 Michelson-Morley experiment, to call the ether-drift results "zero" in spite of the difficulties experimenters have had. Much credit is due Miller for having obtained a dependable set of facts.

# FREE-MOLECULE FLOW

by MARVIN LITVAK EP '56

Superaerodynamics, the aerodynamics of highly rarefied gases, has become increasingly more important to practical engineering now that the rocket airplane has revolutionized our thinking concerning high-altitude flight. The optimum flight altitude of long-range rocket airplanes is approximately sixty miles, at which height the air density is so low that the fluid can no longer be considered to be the continuous medium with which one deals in conventional fluid mechanics. The newer concepts of superaerodynamics, which take into account the coarse structure of the fluid, are needed for rocket-aircraft designing. Because of precautions for national security, little information is available for public knowledge concerning the actual design of rocket aircraft from superaerodynamic considerations. Therefore, we will deal in this article only with the elementary fluid dynamics of superaerodynamics.

The two important problems to be solved in fluid dynamics are: What kind of flow-pattern occurs in the fluid surrounding a moving body or missile, and what are the magnitudes and directions of the forces on the body due to the transfer of momentum between fluid and body?

In order to answer these questions, the aerodynamicist must know whether or not the molecular characteristics of the fluid justify the conventional assumption that the fluid is continuous; that is, he must know: Is the mean-free molecular path, which is defined as the average distance that molecules travel between successive collisions, 1) negligible in comparison to, 2) comparable to, or 3) much larger than the characteristic dimensions of the body? If the first case holds, then he is dealing with conventional aerodynamics. If either the second or third case holds, then he is dealing with superaerodynamics—*slip-flow* occurring in the second case and *free-molecule flow* occurring in the third case (Fig. 1).

In slip-flow, we find that the fluid slips over the body-surface with a definite velocity instead of sticking to the surface to form the well-known stationary boundary layer of conventional aerodynamics. Since most of the problems of slip-flow are still unsolved, we will give no further discussion of this extremely important b anch of superaerodynamics.

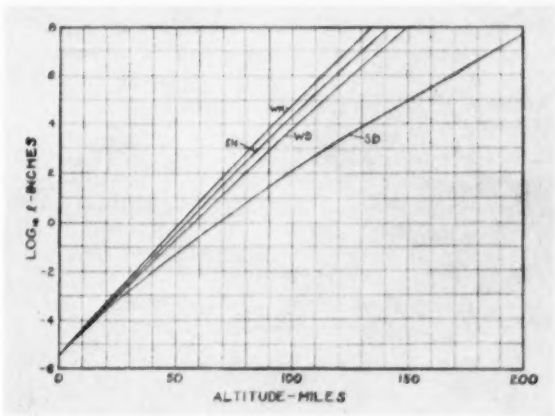
However, a few aerodynamicists, notably Tsien,[1] Stalder,[2] and Zurick,[2] have done work in free-molecule flow. For the sake of analysis, they considered the fluid to be a uniform stream of molecules having a certain mass-velocity upon which they superimposed a Maxwellian velocity distribution to account for the random thermal motion of the molecules (Figs. 2 and 3). Using the condition that the mean free molecular path for free-molecule flow is much larger than the characteristic dimensions of the body placed in this molecular stream, the superaerodynamicists reasoned that collisions between molecules are much fewer than collisions between molecules and the body-surfaces and, therefore, that the stream of impinging molecules is in no way affected by the molecules which are re-emitted from the body-surface. Then they simplified their calculations by considering the transfer of momentum from fluid to body in two stages: 1) the interchange of momentum due to impinging molecules and 2) the interchange of momentum due to the re-emission of the molecules from the body surfaces.

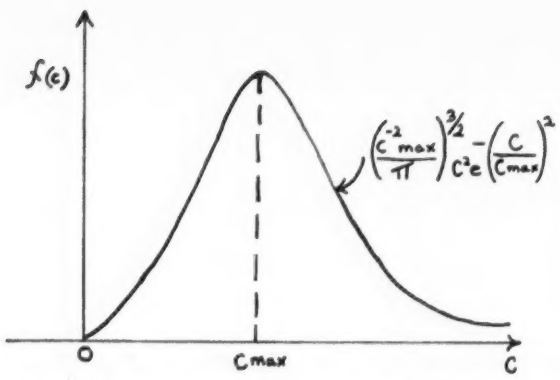
### Molecular Reflection[3]

Experiments show that at least two different types of re-emission of molecules at the body-surface, *specular* reflection and *diffuse* reflection, can occur, depending upon the state and nature of the surface, the kind of gas, the density of the impinging stream, and the temperatures of the gas and the surface.

In specular reflection, the tangential components of velocity of the molecules remain the same upon striking the surface, but the normal components of velocity reverse direction. This is the condition for perfectly-elastic impact, the angle of incidence being equal to the angle of rebound. Specular reflection will occur if surface forces are not too strong; that is, when the surface irregularities are of the order of, or smaller than, the so-called "de Broglie wavelength" of the molecules, as is the case with high-polish specular metal and with very small glancing angles between molecular beam and the surface.

In diffuse reflection, the molecules are reflected from the surface in a completely random manner so that all traces of past histories of the molecules are lost. The direction of reflection is described by a cosine law (the Knudsen cosine law) 149 similar to that of a surface emitting light. The molecules have a Maxwellian distribution of speed which






**Maxwell Speed distribution due to thermal motion alone.**

depends upon the temperature of the re-emitted or scattered stream. This effective temperature, which is proportional to the energy of the scattered stream, depends on the efficiency of the energy-exchange that occurs between the impinging stream and the body-surface. This efficiency can be described by the so-called "accommodation-coefficient," which is independently determined from experiments on heat dissipation. The accommodation coefficient, $\alpha_r$, is defined as follows:

$$\alpha_r = \frac{T_i - T_r}{T_i - T_w} = \frac{E_i - E_r}{E_i - E_w}$$

where:

$T_i$ is the temperature of the incident stream.
$E_i$ is the rate of incident molecular energy.
$T_r$ is the temperature of re-emitted stream.
$E_r$ is the rate of re-emitted molecular energy.
$T_w$ is the temperature associated with a Maxwellian distribution of re-emitted molecules in equilibrium at the surface.
$E_w$ is the rate of energy associated with this Maxwellian distribution.

### Newton's Calculations

Before we enter into the calculations of the aerodynamic forces of lift and drag in the case of an inclined flat-plate in free-molecule flow, let us consider the pioneering work of Sir Isaac Newton concerning nearly the same problem.[5]

The Newtonian fluid consists of a stream of molecules having a uniform speed $v$ but having no thermal motion whatever, an important distinction between Newtonian flow and free-molecule flow. The molecules of Newtonian flow: 1) are either perfectly elastic or perfectly inelastic, 2) are identical and equidistant from one another, and 3) exert no forces on each other in any way.

In elastic or inelastic Newtonian flow, having density $\rho$, a flat-plate which is inclined at an angle $\alpha$ to the stream (see Fig. 4) has a rate of mass impact per unit area of body surface equal to:

$$\rho v \sin \alpha$$

The change of the normal component of velocity is:

$$\begin{cases} 2v \sin \alpha : \text{for elastic impact} \\ v \sin \alpha : \text{for elastic impact} \end{cases}$$

The force normal to the flat-plate, having area $A$, equals the rate of mass impact times the change of normal velocity; that is, the resultant aerodynamic force $F$ on the flat-plate is given by:

$$F = \begin{cases} 2\rho A v^2 \sin^2 \alpha : \text{for elastic impact} \\ \rho A v^2 \sin^2 \alpha : \text{for inelastic impact} \end{cases}$$

which expresses Newton's famous sine-square law.

Drag, the component of force in the flow direction, is given by:

$$F_D = F \sin \alpha = \begin{cases} 2\rho A v^2 \sin^3 \alpha : \text{for elastic impact} \\ \rho A v^2 \sin^3 \alpha : \text{for inelastic impact} \end{cases}$$

therefore, the drag coefficient $C_D$ equals:

$$C_D = F_D / \tfrac{1}{2} \rho A v^2 = \begin{cases} 4 \sin^3 \alpha : \text{for elastic impact} \\ 2 \sin^3 \alpha : \text{for inelastic impact} \end{cases}$$

Lift, the component of force perpendicular to the flow, is given by:

$$F_L = F \cos \alpha = \begin{cases} 2\rho A v^2 \sin^2 \alpha \cos \alpha : \text{for elastic impact} \\ \rho A v^2 \sin^2 \alpha \cos \alpha : \text{for inelastic impact} \end{cases}$$

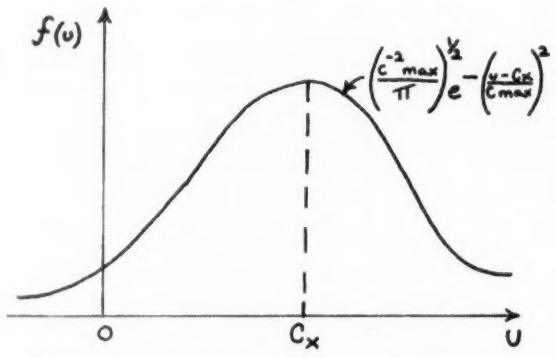
therefore, the lift coefficient $C_L$ is given by:

$$C_L = F_L / \tfrac{1}{2} \rho A v^2 = \begin{cases} 4 \sin^2 \alpha \cos \alpha : \text{for elastic impact} \\ 2 \sin^2 \alpha \cos \alpha : \text{for inelastic impact} \end{cases}$$

These Newtonian-flow calculations erroneously indicate that: 1) the aerodynamic forces are determined merely by the conditions at the front of the body since only this part is ever bombarded by the stream, 2) the pressure on the front face is a constant for a given angle of inclination of the flat-plate and the pressure on the back face is always zero, and 3) the aerodynamic coefficients likewise depend only on the angle of inclination.

Though the results of Newtonian-flow are incorrect for low flow-speeds, at very high flow-speeds, next to which the thermal motion of the molecules is truly negligible, the expressions derived from free-molecule flow theory (specular reflection) do reduce to the corresponding *elastic* Newtonian-flow expressions (a fact which will be shown later).

*Inelastic* Newtonian-flow is not only extremely unlikely




**Maxwell velocity distribution superimposed on uniform mass-velocity. Only the x-component distribution is shown here.**

but probably physically impossible. However, for this flow, the condition that the stream travels right along the body-surface after impact approximates the condition of hypersonic continuum flow, namely, that the shock wave, which springs from, let us say, the leading-edge of the body, lies nearly on the body-surface. As the flight Mach number, $M$, of a flat-plate inclined to the hypersonic continuum flow increases, the Mach angle, defined as:

$$\arcsin \frac{1}{M}$$

becomes smaller, bringing the shock wave closer to the front surface and thereby increasing the pressure on that surface. Meanwhile the amount of expansion on the back surface has increased, thereby decreasing the pressure on that surface. As the Mach number becomes much larger than, say, ten, the pressure on the back surface approaches zero and the pressure on the front surface approaches.[6]

$$(\gamma + 1)\, \rho v^2 \sin^2 \alpha$$

Meanwhile $\gamma$, the ratio of specific heats of the gas, approaches one. We see that the above expression yields the same aerodynamic force that we had before for inelastic Newtonian-flow, namely:

$$2\rho v^2 \sin^2 \alpha\, A\ .$$

### Modern Calculations

Let us now compute the aerodynamic coefficients of a flat-plate in free-molecule flow for the case of specular reflection.[7] The following points should be realized in comparing the expressions to be derived from free-molecule flow theory with those already derived from Newtonian-flow theory: free-molecule flow theory, and not Newtonian-flow theory, takes into account 1) the effect of these molecules which strike the back surface of the flat-plate because they have sufficiently-great thermal velocities toward that surface and 2) the effect (or rather the lack of it) of those molecules which never strike the front surface because they have sufficiently great thermal velocities directed away from that surface.

The resultant aerodynamic force on the flat-plate, inclined at an angle $\alpha$ to the stream, due to both the impinging-inging and re-emitted molecular streams is given by the following general expression:

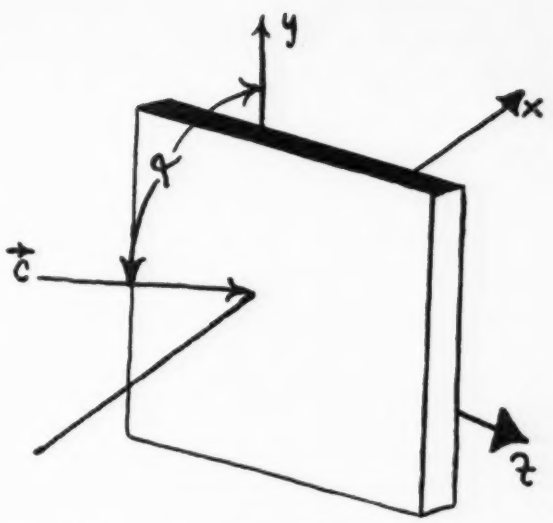
$$F = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} 2\,mu \cdot Au \cdot N\, f(u, v, w)\, du\, dv\, dw$$

where: $(2mu)$ is the momentum transferred to the flat-plate per molecule of the impinging stream.

$(Au)$ is the volume swept out per unit time by the stream of molecules, having normal velocities $\leq u$, which strike area A from either front or back directions.

$[N\, f(u, v, w)\, du\, dv\, dw]$ is the number of molecules per unit volume having velocities between $u$ and $u+du$, $v$ and $v+dv$, $w$ and $w+dw$. Substituting the expression for $f(u, v, w)$,

$$F = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{0}^{\infty} 2\,mu \cdot Au \cdot \frac{N\beta^3}{\pi^{3/2}} \exp\left[-\beta^2(U^2 + V^2 + W^2)\right] du\, dv\, dw$$




Cartesian coordinates used for the problem of the flat plate in a flow of air. Alpha is the angle of inclination of the mass-velocity vector.

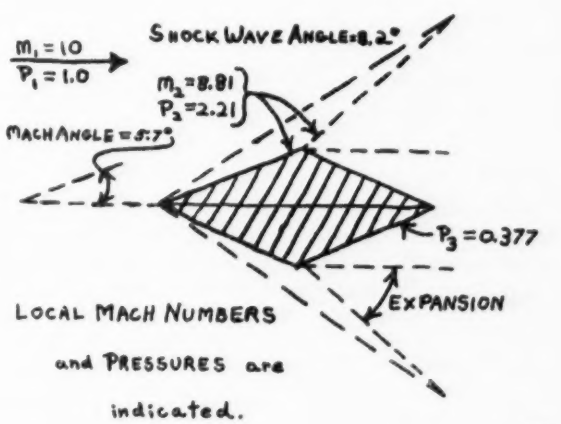
$$-\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{0} 2\,mu \cdot Au \cdot \frac{N\beta^3}{\pi^{3/2}} \exp\left[-\beta^2(U^2 + V^2 + W^2)\right] du\, dv\, dw$$

The first integral term refers to the effects occurring at the front surface, and the second integral term applies to the effects occurring at the back surface.

After use is made of the fact that

$$\int_{-\infty}^{\infty} \exp\left(-\beta^2 V^2\right) dV \cdot \int_{-\infty}^{\infty} \exp\left(-\beta^2 W^2\right) dW = \frac{\pi}{\beta^2}$$

and after the substitution $U = -c_x + u$ is made, the following expression is obtained:




Hypersonic flow past a 6 per cent double wedge at mach number 10. Redrawn from Hilton, W.F., *High Speed Aerodynamics*, Longmans, Green and Co., 1951.

$$F = \frac{2\,m\,N\,A\,\beta}{\sqrt{\pi}} \left\{ \int_{-c_x}^{\infty} (c_x + U)^2 \exp(-\beta^2 U^2)\, dU - \int_{-\infty}^{-c_x} (c_x + U)^2 \exp(-\beta^2 U^2)\, dU \right\}$$

$$= \frac{2\,m\,N\,A\,\beta}{\sqrt{\pi}} \cdot 2 \left\{ 2c_x \int_0^{\infty} U \exp(-\beta^2 U^2)\, dU + c_x^2 \int_{-c_x}^{0} \exp(-\beta^2 U^2)\, dU + \right.$$

$$\left. 2c_x \int_{-c_x}^{0} U \exp(-\beta^2 U^2)\, dU + \int_{-c_x}^{0} U^2 \exp(-\beta^2 U^2)\, dU \right\}$$

$$= \frac{2\,m\,N\,A\,\beta}{\sqrt{\pi}} \left\{ \beta\, c_x \exp(-\beta^2 c_x^2) + 2(\beta^2 c_x^2 + 1)\, \frac{\sqrt{\pi}}{2} \operatorname{erf}(\beta c_x) \right\}$$

Since $s = c/c_{max} = \beta c = \beta c_x \sin\alpha$

$$F = \frac{\rho\, c^2\, A}{2} \cdot 4 \left\{ \frac{1}{s\sqrt{\pi}} \sin\alpha \exp(-s^2 \sin^2\alpha) + \left( \sin^2\alpha + \frac{1}{2} \right) \operatorname{erf}(\beta s \sin\alpha) \right\}$$

The drag coefficient is then given by:

$$C_{DS} = 4 \sin\alpha \left\{ \frac{1}{s\sqrt{\pi}} \sin\alpha \exp(-s^2 \sin^2\alpha) + \left( \sin^2\alpha + \frac{1}{2s^2} \right) \operatorname{erf}(\beta s \sin\alpha) \right\}$$

and the lift coefficient is given by:

$$C_{LS} = 4 \cos\alpha \left\{ \frac{1}{s\sqrt{\pi}} \sin\alpha \exp(-s^2 \sin^2\alpha) + \left( \sin^2\alpha + \frac{1}{2s^2} \right) \operatorname{erf}(\beta s \sin\alpha) \right\}$$

We will now see that these last two expresisons reduce to the corresponding Newtonian-flow expressions when the thermal velocities become negligible next to the mass-velocity $c$; that is, let us make $s$ approach infinity:

Then

as $s \to \infty$

$\lim C_{DS} = 4 \sin\alpha [\sin^2\alpha]$

$\lim C_{LS} = 4 \cos\alpha [\sin^2\alpha]$

since $\operatorname{erf}(\beta s \sin\alpha) \to 1$, as $s \to \infty$

## Summary

We have shown by the example of the flat-plate in free-molecule flow the method used in this branch of superaerodynamics. The expressions given above for the force $F$ are perfectly general if one considers the surface of a body of arbitrary shape to consist of differential plane areas $dA$. If $A$ is replaced by $dA$ in these expressions, one now has the expressions for the *differential* contribution $dF$ which is to be integrated over the body-surface to yield the resultant force $F$. The general method by which these expressions were obtained was seen to be a refinement by means of kinetic molecular theory of the pioneering work of Newton.

Besides the mechanics of free-molecule flow, the superaerodynamicist must be concerned with the heat transfer processes in the region of free-molecule flow. At high speeds and high altitudes, one encounters overheating of missile structures due to frictional heating, an effect which is responsible for the decomposition of meteorites in the upper atmosphere. The theoretical problems of heat transfer are solved by obtaining expressions for the balance of incoming and outgoing energy at a section of the skin of the missile; the previously defined accommodation coefficient frequently enters into these calculations. At an altitude of 150 miles or more, solar radiation, and not skin friction, is the predominant factor in determining skin temperature.

Experimental work in superaerodynamics has yet to catch up with much of the theoretical work outlined in this article.

### *Notation*

$A$ Surface area of one side of a flat-plate.
$\alpha$ Angle of attack of the flat-plate with respect to the free stream.

$\beta = \frac{1}{c_{max}}$ ($c_{max} \equiv$ most probable molecular speed)
$C$ Mass velocity having components $c_x$, $c_y$, $c_z$.

$C_x$, $C_y$, $C_z$ } Components of mass-velocity.
$c_{max}$ Most probable molecular speed.
$C_D$ Drag coefficient } Subscript "$s$" means "due to specular
$C_L$ Lift coefficient } reflection."
$\gamma$ Ratio of specific heats of the gas.
$F, F_D, F_L$ Aerodynamic force, resultant drag, resultant lift.
$m$ Mass of a molecule.
$M$ Mach number, the ratio of $C$ to speed of sound.
$N$ Number of molecules per unit volume.
$\rho$ Mass per unit volume $= mN$.
$s$ Molecular speed ratio $C/c_{max}$
$u$, $v$, $w$ } Components of total molecular velocity.
$U$, $V$, $W$ } Components of thermal molecular velocity.
$v'$ Newtonian-flow mass velocity.

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# WATER UTILITY MANAGEMENT

by JAMES SYMONS CE '54

Water is the cheapest commodity in existence; ten tons for a dollar or 385 glasses for a cent. Few persons realize just how cheap water is and fewer still realize how inexpensive is the delivery of water. The consumer turns on the faucet, expects and gets clear, safe water, whenever he wants it in whatever quantity he desires. And what does this most important service in the community cost?—Four dollars for the first 1000 cu. ft., and 33 cents a 100 cu. ft. for the next 4000 cu. ft. delivered through a 5/8-in.meter. These figures sound inexpensive, but when one realizes all of the routine involved in providing that water at the consumer's tap, the cost seems even less.

The many problems of supplying water became apparent to the author when he worked in the office of the Westchester Joint Water Works No. 1 in Mamaroneck, N. Y., in the summer of 1953. The office work alone involved in getting water to a new consumer is interesting, complex, and detailed. When the details were tabulated as part of a study of office operations, it became evident that procedures could be organized into six categories. It is the purpose of this article to set forth these detailed procedures for the benefit of others who may be faced with similar problems.

### The Utility

The Westchester Joint Water Works No. 1 is unusual in this respect: It is owned by three political entities, the Town of Harrison, the Town of Mamaroneck, and the Village of Mamaroneck, in Westchester County, just outside of New York City. Besides supplying these communities, it also serves portions of New Rochelle and the City of Rye. The utility obtains its water from a small impounding reservoir on a small stream. It serves 40,000 customers through 7000 meters, and owns a 6.0 mgd rapid sand filter plant, and a 7.5 mgd pumping station which pumps New York City water (with chlorination only) when the stream flow is insufficient.

Operation of the utility is under the management of a board representing the three communities. The office is located in Mamaroneck, New York, and is managed by a chief clerk who supervises this staff: senior stenographer, stock clerk, billing machine operators, accounting machine operator, cashier, billing clerk (who assigns work to the service men), junior clerk and telephone operator. This office staff plus the plant operators and maintenance crew handle the job of water supply in these suburban communities.

The problems of office management in reference to new services are classified in six functions or stages: (1) preliminary to service connection, (2) tapping, (3) meter purchasing procedure, (4) meter installation, (5) billing, and (6) clerical work at the end of the month. The first step begins when a local developer, who owns land in one of the districts, decides to put in a new street and build houses.

### Preliminary to Service Connection

The builder must bring plans for his development to the water office for review by the superintendent, who determines the size of main needed to meet the expected demand, according to the sizes of the houses to be built and the number of water-using appliances to be installed. The superintendent must also determine from the expected demand whether or not the development can be supplied from existing mains; if not, plans must be made to reinforce the network of mains. Once the main size has been decided, the superintendent prepares an estimate of the cost of the work by listing the materials needed with prices obtained from the stock book. The completed estimate is given to the senior stenographer, who checks and types it in duplicate, one copy being sent to the board (governing body) of the district in which the development is to be constructed, the other copy being sent to the developer (contractor).

The district board reviews the estimate and plans, taking into account the zoning laws, general development of streets, etc., to determine if the project will fit into the present scheme. If satisfactory, the development plan is approved. The developer must then deposit with the water utility the estimated cost of the work and the district board sends approval to do the work to the water office. At the next regular meeting of the water utility board the approval of the district board is reviewed, and if approved, a resolution is passed to proceed with the work. The estimate is then assigned an authorization number and filed. A copy of the estimate is given to the chief clerk for comparison with the actual cost of the work.

The work of laying the main begins with the contractor digging the trench for the main. When the water office is notified that the trench is ready, the maintenance foreman, after obtaining the necessary street opening permit, assigns men to the job; they pick up the needed materials from the pipe yard, proceed to the location and lay the main. When the job is completed, one of the maintenance crew inspects, tests, and sterilizes the

**After clearing with the water utility office, work is begun on a 1½ line, which will supply water to parts of a proposed building.**

main with HTH, a high test hypochlorite.

Before the trench is backfilled by the contractor, the maintenance foreman measures the line, lists all of the appurtenances installed, and makes out his report on the material actually used. This report goes to the stock clerk and then to the chief clerk, who figures the actual cost, and the amount of the estimate (which was on deposit) may then be settled with the contractor. A sketch of the main is then made for inclusion in the authorization file and the new street is drawn on the master map of the streets in the district.

### Tapping

The various steps and office details involved in the tapping category include these, in the order of performance.

1. Builder must file, in duplicate, an application for the tap and pay for it at the charges set forth above.

2. Cashier accepts payment, posts it in the cash register and makes a folder for the amount file.

3. Builder deposits with the cashier the amount of the estimated charge for water to be used during building.

4. Location card and charge memo (indicating amount paid) are made out by cashier.

5. The location of the property is verified on the assessment map and the new account number is entered thereon.

6. A ledger sheet for the account, prepared by the junior clerk, and the charge memo goes to the accounting machine operator, who enters the charges and credits on the ledger sheet and files it in the ledger sheet "buggy."

7. Cashier makes out a tapper's report showing house location, size of tap, size of main, and account number. This report then goes to the billing clerk.

8. On receipt of a report from the builder or contractor that a trench to the house is ready, the billing clerk assigns a tapping crew to the job.

9. After the service is installed the tapper's report is completed to show a sketch of the curb box location and all materials used.

10. The completed tapper's report goes to the stock clerk, who notes the materials used and then gives it to the junior clerk, who files it in the account file.

### Meter Purchase Procedure

The water works utility keeps a number of meters of all sizes in stock and purchases them in lots of 24 or more. For the purpose of this discussion the purchase procedure will be outlined for a single meter.

1. The purchase is originated by meter repair foreman and approved by the superintendent, in his capacity as purchasing agent, by making out a meter requisition.

2. In accordance with the requisition, the stock clerk prepares a purchase order, in triplicate. One copy (yellow) goes to a permanent files, one (pink) goes to the meter repair foreman who will receive the meters. The original is signed by the superintendent and mailed, with a claim, to a meter manufacturer.

3. When the meter is received, the cashier makes out a meter card, on which the serial number is entered. On this card will be entered the complete history of the meter in service, its installations, removals from service, repairs, etc.

4. When the meter is received, the pink copy of the purchase order is checked against the invoice by the meter repair foreman and both are returned to the stock clerk.

5. When the manufacturer's notarized claim is received by the senior stenographer, it too goes to the stock clerk for checking.

6. The claim, invoice, and pink copy of purchase order next go to the chief clerk, who enters the amount and manufacturer in the voucher register.

7. The cashier draws a check for the amount in question and enters this amount in the cash book.

8. The claim and check go to the superintendent and auditor for approval. At the next meeting of the water works board the chairman and treasurer of the board sign the check and it is mailed to the manufacturer.

9. The claim, invoice, and pink copy of the purchase order are filed. When the cancelled check is returned, it, too, is filed.

Thus, the records of meter, or any other, purchases become a part of the permanent files of the utility.

### Meter Installation

When the builder has used up his building water allottment, a meter must be set. A meter installation card is issued in duplicate, and the standard installation fee is charged to him. These standard fees are:

| *Size of Meter* | *Amount* |
|---|---|
| 5/8-in. | $ 6.00 |
| 3/4-in. | 7.00 |
| 1-in. | 8.00 |
| 1½-in. | 10.00 |
| 2-in. | 12.00 |

When the meter is to be set, the billing clerk is notified, the work assigned. The men pick the meter up from stock, set it, and fill in the necessary information on the meter installation card, the original being returned to the cashier, who files it in her permanent file and creates a meter reading page by noting the meter serial number and the date set on a blank reading page. This page is then placed in a meter reading book in its proper relation to the neighboring houses.

The copy of the installation card is given to the junior clerk, who copies the information on the proper ledger sheet, types a card to be used in the addressograph plate holder, and stamps an addressograph plate with the Graphotype machine. This plate is used for billing purposes and has embossed on it the builder's name, address, account number, and meter reading book and page number.

Since the builder has had the meter set, he includes the cost of installation in the price of the house. Therefore, the new owner must notify the water office of his purchase so that the records may be corrected. This notice is given to the senior stenographer, who mails an application to the new owner for his signature. When this is returned, the addressograph plate, meter reading book page, and the ledger sheet are changed and the record correction is thus completed. When these corrections have been made, the meter installation is completed and so is the unique routine for new houses.

**Billing Procedure**

In contrast to the above, what follows is a day by day, month by month routine. Although each house is billed once every three months, the staggering of the three districts makes billing a continuous procedure:

1. The consumer uses the water for three months.

2. The meter reader enters the consumer's home and notes the dial reading in the meter book. If no one is home, the reader leaves a self-addressed postcard on which the occupant can copy the dial reading and mail it into the office.

3. When the reader has been through the meter book once, it is given to the billing clerk, who computes the metered water charges.

4. The billing clerk notes any houses that have been skipped and assigns service men to obtain the readings if no postcard is received. If this repeat trip to the house fails to obtain a meter reading, the bill is estimated.

5. The junior clerk prints the address of the consumer on a blank bill with the addressograph machine, checks the billing clerk's computations, and gives the checked book and the corresponding addressed bills to the billing machine operator.

6. The operator prints the account number, inclusive dates, before and after dial readings, consumption, charges, arrears if any, and the amount due on the bill. By a carbon arrangement this information is also printed on the corresponding ledger sheet, and on a proof sheet.

7. A check is then made of the total consumption and money due from the meter reader's book against the total on the proof sheet, and the checked total is entered on a control sheet by the billing machine operator.

8. The bill, plus a return envelope, is stuffed in an envelope, stamped, sealed, and mailed.

9. If payments are made by mail, they are separated into districts and labeled with the proper account number.

If the payment is in person, the cashier receives the money and posts it in the cash register.

10. Payments by check are posted in the cash register and the stubs (half of the bill) are put in the register drawer along with the checks. The other half of the bill is put in an envelope and returned to the customer as a receipt.

11. At the end of each day, stubs are sorted into districts, the total cash received for each district is entered in the cash receipts book by the cashier, and the stubs turned over to the accounting machine operator. Daily receipts are then totaled, entered on a deposit slip, and deposited in the bank.

12. When the accounting machine operator receives the stubs, the amount of each stub is entered on its corresponding ledger sheet and a carbon copy of the entry is made on a proof sheet.

13. The totals on the proof sheet are checked against the total cash received for the day as shown in the cash receipts book, and when agreement is reached, the proof sheet is stamped "control," and the totals are entered, and it is filed.

14. Periodically all of the ledgers must be checked for delinquent payments, bills being due the last day of the month following the one in which it is received.

**Employee of a water utility operates this accounting machine. Shown in the foreground are 'buggies."**

15. The accounting machine operator checks for lateness and if any is found, she adds two per cent to the bill, makes out a collection slip, and gives it to the bill collector. The collector visits the home and tries to collect the money.

16. At the end of each day the cashier receives the collector's money and handles it in the same manner as described above.

This completes the day-by-day routine, but one more item in the billing procedure should be mentioned. Once a year each district requests the delinquent bills of their district as of a certain date and these are collected as a tax lien. In the areas served outside the three districts a deposit is required to guard against overdue bills.

### End of the Month

Several reports and closing entries are made only once a month and they are as follows:

1. The stock clerk makes out the monthly report of the material used in all of the jobs during the month.
2. The total months consumption and money due from the control sheet is entered in the journal.
3. The collection control sheet is reported to the chief clerk and is balanced against the total of the cash receipts book.
4. The billing machine operator checks the total of the outstanding balances on each account against the total outstanding balance on the control sheet of the next district to be billed.
5. The cashier checks the bank statement and notes the outstanding checks.
6. Any adjusting entries due to adjusted accounts receivable, insurance payments, payroll distribution, and the like are entered in the journal voucher so that all accounts will balance.
7. The utility repays the contractor (developer) a portion of the money he spent to construct the main. The repayment scheme varies from district to district, but essentially the developer gets a certain percentage of the receipts for a certain number of years.
8. The utility pays the three districts enough to defray the interest and redemption of the water works bonds. Water rates are fixed to cover operating costs plus the charges mentioned above.

### Other Services

Thus far this paper has outlined the office detail connected with installing services, billing and collecting, etc. The utility also provides other services and the office force performs other duties that should be mentioned in passing.

1. Handling of complaints
   a. High consumption
   b. Low consumption
   c. Dirty water
   d. Poor pressure
   e. Leaking meters
   f. Noisy meters
   g. Stuck meters
2. Handling of requests
   a. Filling swimming pools
   b. Change in size of service or meter
   c. Rendering a final bill
3. Clerical work
   a. Figuring salaries and overtime
   b. Keeping records up to date
   c. Keeping office supplies on hand
   d. Taking care of all correspondence, reports and schedules
   e. Keeping minutes of the utility board meetings
   f. Answering telephone calls

These duties and services are those of the office force. In addition there is, of course, the operating staff which performs the many tasks of collection, purification, and distribution of water, plus maintenance work including: repairing leaks, checking hydrants, locating valve boxes, and testing, repairing and replacing meters.

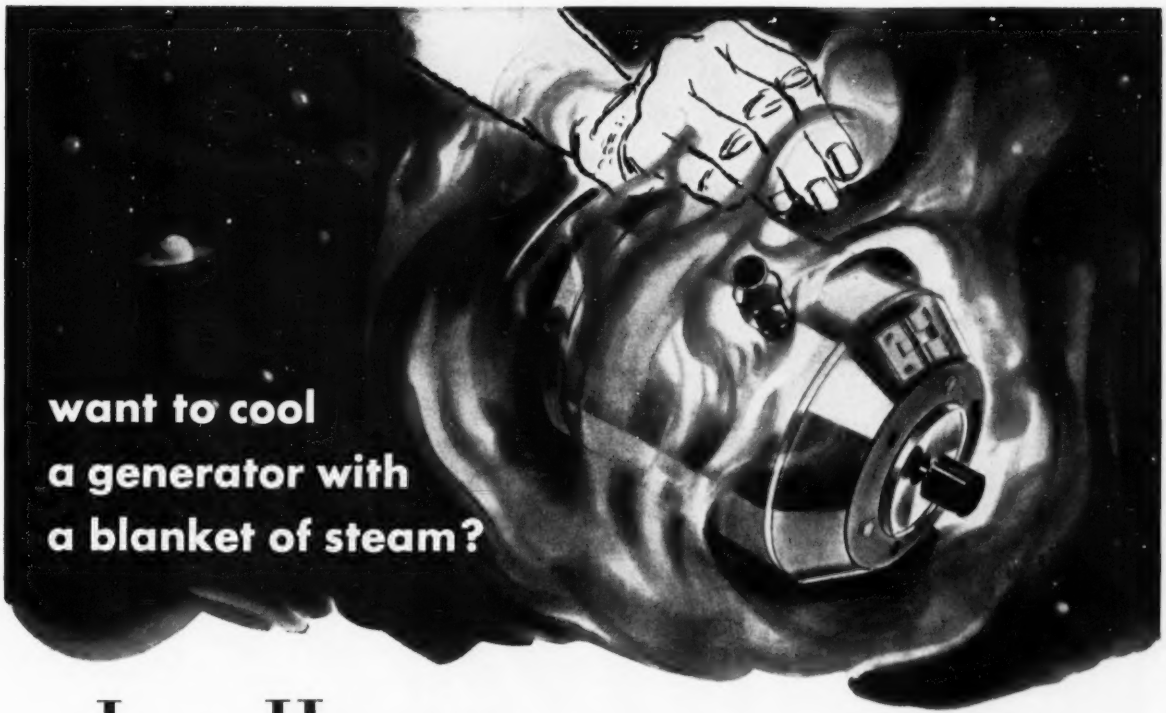
**The water utility office directs the serviceman to "trouble spots." Here a repairman is showing servicing a meter which has stuck.**

### Summary and Comment

It is not only the large water works, but the small ones as well which perform an amazing amount of service for so little cost to the consumer. While other costs have increased, water and the service which puts it in the customer's home is still cheap. Good as water service is, it could be better if water rates were increased but a fraction of a cent per person per day.

Considering the number of steps involved in the procedures outlined above, it may appear to the casual observer that the work is quite involved with the transfer of papers and reports from one person to another. This is not true, however; the procedure is much like a mass production assembly line with each worker doing a small job, and in its proper sequence these many jobs accomplish the major one, keeping track of the supplying of water. When each person has a small routine function, it can be efficiently performed and this lends efficiency to the whole organization.

(*Continued on page 38*)

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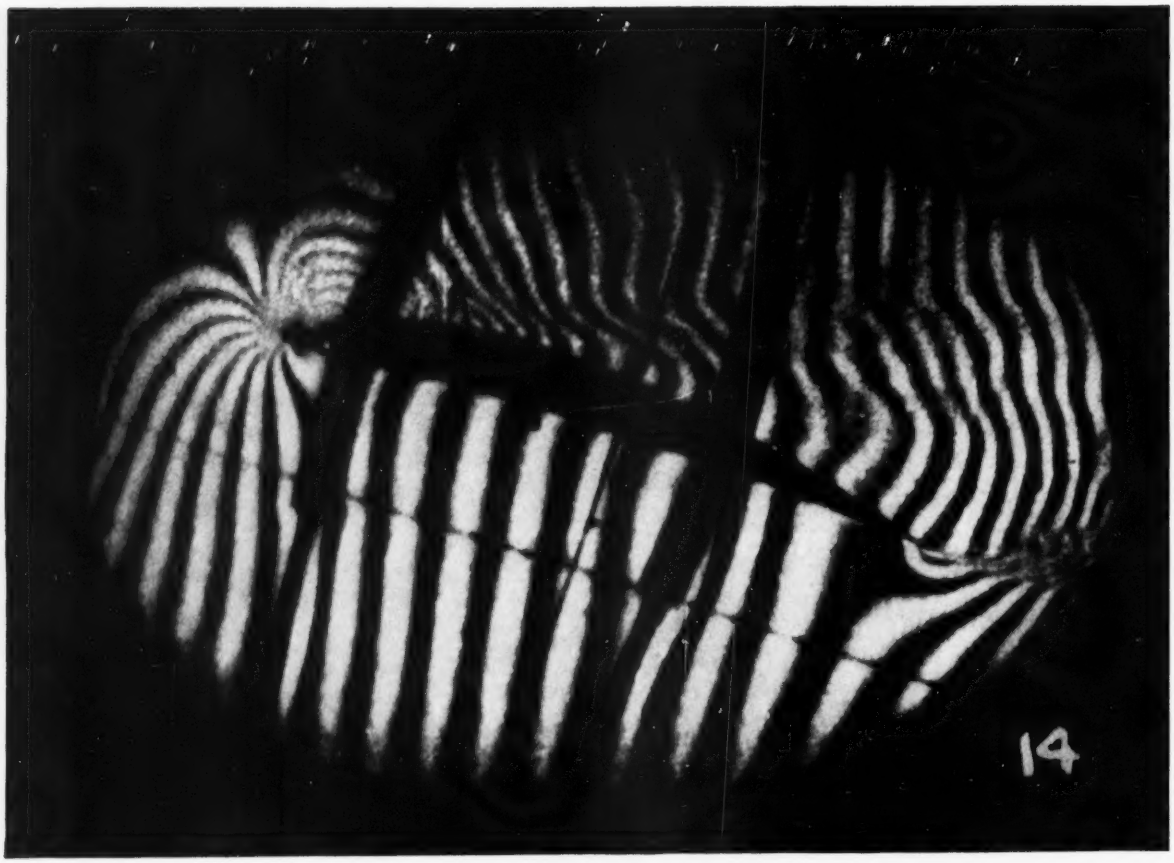


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# THURSTON HALL EXHIBITS

Engineering materials and their uses in everything from sports equipment to automobiles are now being shown in a series of public exhibits in the lobby of Thurston Hall, Cornell's new engineering-materials center. The Department of Engineering Materials and Mechanics is sponsoring the series to keep the public, as well as engineering students, abreast of the latest developments in the materials field. Emphasis is placed on the scientific and engineering developments with special reference to materials and their selection, preparation, processing, and inspection. During the next few months, visitors will see how engineering and engineering materials play a vital role in the manufacture of sporting goods, glass, automobiles, and plastics.

In January, the International Nickel Company featured a display called "The Romance of Nickel" showing how nickel is produced and why it is so important to our country. Also on display were platinum spark plugs, precious-metal jewelry, the nickel-cadmium battery, television components, and many other industrial items. The platinum metals—platinum, palladium, osmium, ruthenium, rhodium, and iridium—were also exhibited. Many saw for the first time the revolutionary new metal, ductile iron, which can be worked like steel but yet retains the castability and ease of machining of cast iron.

In February, the New York Telephone Company arranged a display on some of the materials and processes of the communications industry. Featured in the exhibit were the "500" set, a new telephone instrument developed by Bell Telephone Laboratories which can deliver a voice ten times more powerfully than conventional equipment, and the transistor, a pea-sized amplifier which may replace the vacuum tube and make possible many startling electronic developments.

Also included in the exhibit were: relays and switches that are used in automatic switching of calls in a central office; the wire wrapping gun, a pistol-like tool that literally shoots wires onto terminals to make solderless connections; types of telephone wire and cable, showing cross-sections of each kind; and the Morton tube, the heart of a telephone radio relay system which receives electric current from a wire sixtieth of the thickness of a human hair.

In addition, there were two large exhibits, one on micro-wave transmission of television and telephone traffic, and another on the advances made in telephone instruments from 1878 to 1954.

For the latter part of February and the beginning of March, the Bakelite Company sponsored a display on plastics. This exhibit included the method of production and sundry applications of polystyrene, polyvinyl chloride and polyvinyl chloride copolymers, phenolics, and urea formaldehyde. In addition, there was a display on polyethylene and its relatively new uses in piping high-frequency wire insulation, handling corrosive chemicals, and food packaging.

—*Photo Science*

**Radio relay system display by New York Telephone Company.**

From March 12 until April 1, the Wilson Sporting Goods Company showed an exhibit on engineering's influence in making spring and summer sporting equipment. Other exhibitors this spring will include: Corning Glass Company, Chrysler Corporation, and the Cornell Aeronautical Laboratories.

**International Nickel Company's exhibit in the lobby of Thurston Hall. At left is the rare metals display.**

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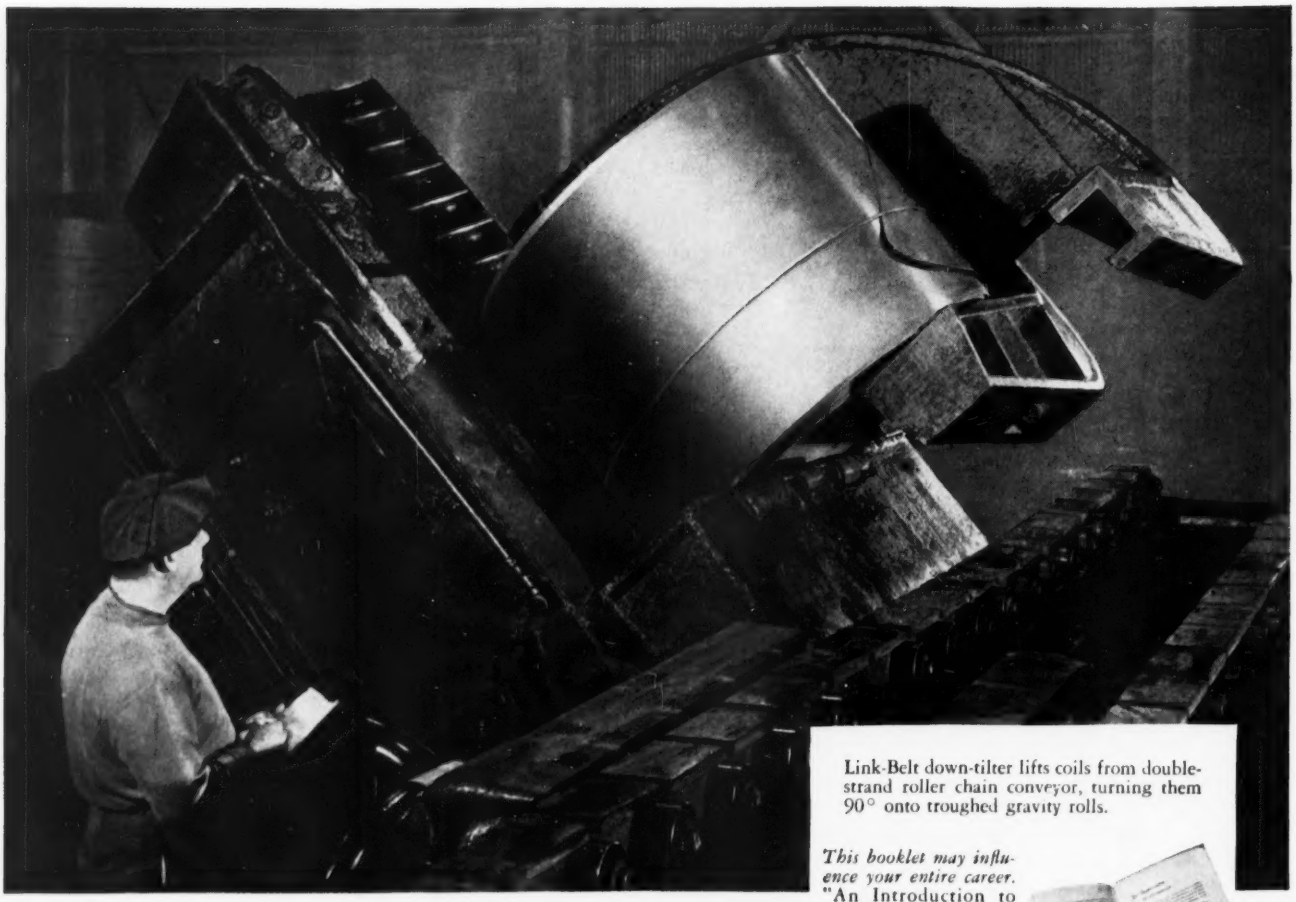

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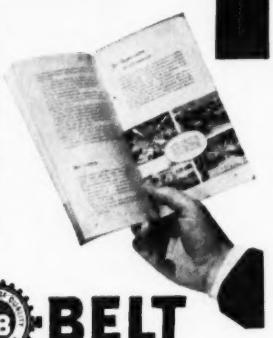

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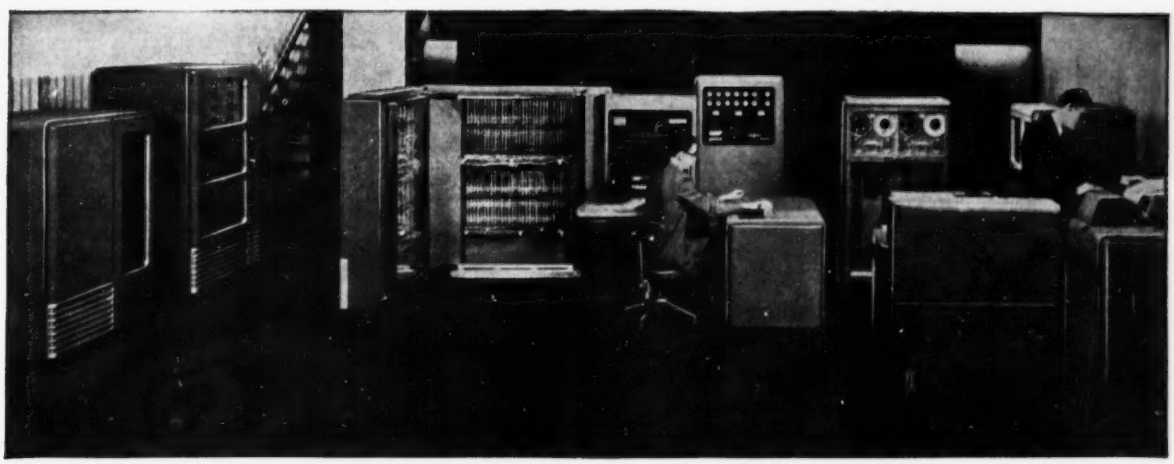

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Professional and business life is a continuation of this competitive system. A college man entering business employment leaves one arena for another. He is expected to apply himself rigorously to the job at hand and to each successive assignment.

Company representatives, interviewing engineering seniors for employment, look for character, intelligence, personality, and other basic qualities that indicate future growth and development of the individual. Scholastic records are probably the best indicators of these qualities. A good record shows that the student has attached sufficient importance to his studies to excel in them, thereby indicating good judgment and honesty of purpose.

There are instances where scholastic records do not accurately portray the man—an individual may have potential qualities that have not fully developed because of poor secondary school preparation, immaturity due to comparative young age, or difficult adjustment to the college environment. Such conditions may prevent a man from making an outstanding record during his college years.

There are instances of outstanding college men ending their careers in mediocrity both in business and private life. Conversely, twenty years from now, some one of the graduating class who appears rather insignificant today will have achieved outstanding success through the development of basic personal qualities which at the moment are obscure.

Some people, usually the unsuccessful ones, consider success to be a matter of luck. They attach the greatest importance to being in the right place at the right time. This is a consideration that is greately exaggerated. No one person has all the luck, and success was never based on luck alone. On the face of it, you can do nothing about luck. Either you have it or you don't, so why worry about it?

On the other hand, you can work hard, develop ability, and set up a record for accomplishment that will make you a valuable man in any organization. Sooner or later circumstances will present a fortunate opportunity to you. Such opportunity comes to every one at some time or another. Make sure you are prepared to make the most of each opportunity as its arises.

Selecting a company for employment permits you to start in the particular industry that interests you. This is an advantage not possessed by graduates in "depression" years. You should make the most intelligent choice of positions available to you, taking into consideration the immediate assignment and the long-range view. Persist in your campaign for progressive accomplishments and your attainments will merge into a successful career.

# ALUMNI ENGINEERS

**Harry Josiah Clark, M.E. '95,** died on December 8, 1953, at his home at 123 West Borden Avenue, Syracuse. He was deputy superintendent in charge of plant and finance of the Syracuse school system until his retirement in 1945. From 1919-26, he was commisioner to the Syracuse Board of Education, and then became president of the board. Clark was Alumni Fund representative for the Class of '95. Phi Kappa Psi; Sphinx Head.

**C. P. Wood, M.E. '04,** industrial engineer with Lockwood Greens Engineers, Inc., New York, contributed the article on Factory Construction and Planning in the current edition of Encyclopaedia Britannica.

**Lloyd Balderston Jones M.E. '04,** RD 2, Malverne, Pa., died in June, 1953. He was an engineer with Pennsylvania Railrod and had been with the railroad for forty-four years before retiring in 1948. Jones, who held fifteen US patents on engineering devices was a fellow of the American Society of Mechanical Engineers, a member of The Franklin Institute, Philadelphia, Pa., and a past-president of Kiwanis. Son, **Charles W. Jones '34.**

**Francis N. Bard, M.E. '04,** president of Barco Manufacturing Co., manufacturers of railway devices, has moved his factory from Chicago, Ill., where it was located for more than forty years, to a new factory at 500 North Hough Street, Barrington, Ill. Bard continues to operate his farm near Crystal Lake, Ill., and his ranches in Arizona, where he is developing a new breed of cattle suitable for Southwestern semi-arid and mountainous country.

**Alexander Norton Bentley, M.E. '04,** died on November 5, 1953, in Rochester. Until his retirement in 1939, he was with Electric Storage Battery Co., Philadelphia, Pa. He had been with the company since 1907 and had managed its subsidiary, Exide Batteries of Canada, Ltd., Toronto, Canada, since 1919. Bentley, who lived at 21 Oak Street, Geneseo, was a member of the Society of Automotive Engineers and formerly chairman and director of the budget committee of Federation for Community Service, Toronto. Psi Upsilon.

**Lysander D. Childs, M.E. '06,** died on November 6, 1953, in New York City, where he lived at 400 East Fifty-ninth Street. He retired in 1947 as an examiner with the Reconstruction Finance Corp. in New York and had formerly been with the bond department of Guaranty Trust Co. Phi Delta Theta.

**Thomas Riggs Cox**

**Philip Will, M.E. '07,** 7 Highland Heights, Rochester 18, writes that he is an amateur gardner, now registered in a home gardening corresponding course, and still able to swing an axe or push a cultivator. He would be glad to exchange experience with anyone interested in vegetable and fruit culture. He says that he can also tell them something about child training, since for the last four years he has turned his bedroom into a playroom for two grandchildren, whose mother is afflicted with polio.

**Harry A. Patten, C.E. '07,** 13 Furches Street, Raleigh, N.C., retired from US Department of Agriculture last May and is now Radio Farm Director for Tobacco Network. He broadcasts a daily farm program which covers most of eartern North Carolina.

**Peter T. Vanderwaart, M.E. '09,** retired last month after thirty-eight years with New Jersey Zinc Co., as electrical engineer, mechanical engineer, assistant chemical engineer, and manager of manufacturing. He is spending the winter at 340 Beach Drive North, St. Petersburg, Fla. His permanent address is Residence Park, Palmerton, Pa.

**Frederick Luther Lucker, M.E. '09,** RD 1, Rock Hall, Md., died on June 23, 1953. For many years he was in the engineering and sales department of Ingersoll Rand Co., New York City. During World War II, he served with the War Production Board. Brother, **Grover Lucker '06.** Theta Lambda Phi.

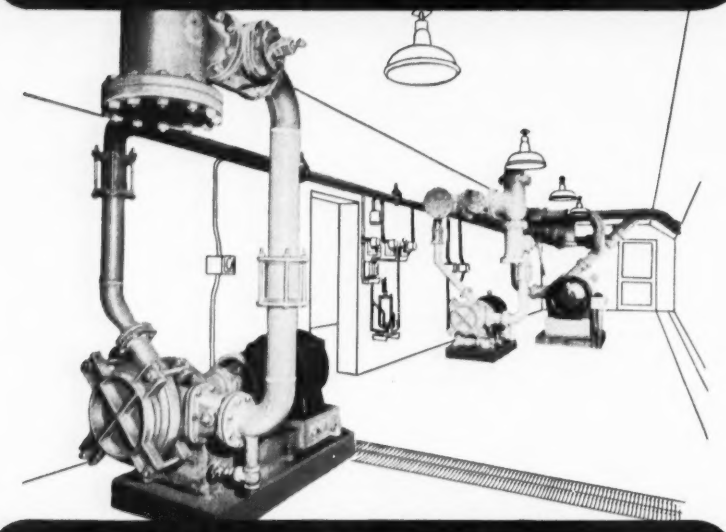
**George David Curtis, C.E. '09** died on October 25, 1953, at his home, 3420 Santiago, Tampa, Fla. He was treasurer and general manager of the Yacht Basin Apartments, Clearwater Beach, Fla., and formerly had been president of the Morris Plan Bank in Tampa and executive secretary of the Greater Tampa Chamber of Commerce. Son, **George D. Curtis, Jr. '40.**

**George Walter Blair, M.E. '10,** retired president of Mishawaka Rubber & Woolen Manufacturing Co., subsidiary of US Rubber Co., and president of the First National Bank of Mishawaka died October 24, 1953, at his home, 354 Edgewater Drive, Mishawaka, Ind. He had also served as development manager of the footwear and general products division of US Rubber Co. He headed a recent United Fund campaign which raised $1,000,000 for the work of thirty-two agencies in St. Joseph County, Ind. Seal & Serpent.

**Thomas Riggs Cox, M.E. '11,** is living at 250 West 23rd St., New York 11. From 1923 to 1942 he was an active floor member of the New York Stock Exchange. In 1944 he joined the Broadway Savings Bank and became its president in 1946.

**Howard W. Dix, M.E. '11,** was elected in the spring of 1953 by the New York Patent Law Association as 2nd Vice-President and as Chairman of Admissions Committee.

## Handles extremely thick slurries with high specific gravities



## MORRIS Type R SLURRY PUMP

Heavy viscous slurries with solids ratios as high as 70% by volume are not unusual loads for a Morris Type R Slurry Pump.

A case in point is this Morris installation at the Missouri Portland Cement Co., St. Louis, Mo. The two Morris 3R Pumps in the foreground each handle 200 GPM of a cement slurry at 64% solids with 1.66 specific gravity. Speed is 1180 RPM. The 6R Pump in the background handles 600 GPM of the same slurry at 880 RPM.

### Long operating life... little or no maintenance

Massive running parts of the Type R compensate for the increased load imposed by high specific gravities. Hydraulic passages are deliberately designed for high concentrations of solids—the result of careful study of wear patterns shown by pumps in the field handling all kinds of abrasive materials. Elimination of areas of throttling and turbulence assures uniform wear of all parts.

There are no internal studs or bolts—no troublesome internal joints and fits. The suction disc liner is merely *clamped* into position between disc and shell. The absence of high stress on the shell permits wide variations in its composition—including materials of high abrasive resistance—to resist wear and extend the operating life of the pump.

Let our engineers consult with you on your slurry pump problems. They'll give you the benefit of 88 years of pump-building experience. Or, write for Bulletin 181.

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MORRIS *Centrifugal Pumps*


**Carl Conrad Cooman, C.E. '15,** connected with the Rochester Gas and Electric Corporation since 1923 and in charge of their structural design operations since 1935, died in Rochester, N.Y. on October 7, 1953. Prior to 1923, Mr. Cooman was employed by the Portland Cement Association; C. H. Sage of Batavia, N.Y.; and the Rochester Bureau of Municipal Research. He served as president of the Rochester Section of the ASCE in 1934 and was chairman of the Section's Qualification Committee at the time of his death.

**John George Dorsey, C.E. '16,** died March 4, 1953 as the result of an airplane accident in Meade County, S. Dak. He was with N.W. Engineering Co., Rapid City, S. Dak., where he lived at 609 West Street. Alpha Kappa Sigma.

**Robert Edwin Keefe, M.E. '17,** of 21 Laurel Avenue, Windsor, Conn., since 1926 safety engineer at Aetna Casualty & Surety Co., Hartford, Conn., died on November 6, 1953. From 1934-51 he served as safety director of the American Legion, Department of Connecticut.

**William E. Blewett, Jr., M.E. '18,** was elected president of Newport News Shipbuilding & Dry Dock Co., Newport News, Va., December 16. Blewett, who had been executive vice-president since 1947 joined the company in 1918. He lives at 21 Museum Drive, Warwick, Va.

**Damon G. Douglas, C.E. '19** has recently been elected chairman of the Board of Chosen Freeholders of Essex County, New Jersey. Although he finds that much of his time is spent on county affairs, he still finds time for playing chess and manageing his own construction company.

**William F.** (Sam) **Bernart, Jr., M.E. '24,** and his wife, the former Louise Bryan of Elmira, recently returned from a six-weeks' trip to Europe. Their daughter, Sally, was married on September 26 to Peter Haaren. Peter is in the Credit Department of the New York Trust Co. He and Sally live in Manhattan. The Bernarts, who live on Ponus Ridge, New Canaan, Conn., have two sons, Bill, a Princeton graduate, and **Bryan,** who attended Cornell, Class of '50.

**Carlyle M. Ashley, M.E. '25,** is celebrating his 30th year with Carrier Corporation in Syracuse, having worked for Carrier one year prior to entering Cornell. He is chief staff engineer for the company. He has been active in the American Society of Heating and Ventilating Engineers and the American Society of Refrigerating Engineers. He is the holder of some 40 patents covering a wide range of subjects. Carlyle is president of the Board of the Syracuse Museum of Fine Arts. His other interests include gardening and high fidelity musical reproduction. His son, **George '54,** is a Senior at Cornell in Electrical Engineering. Another son, David is in his 4th year at Syracuse University where he is studying architecture. His daughter, Joanne, is a graduate of Syracuse University in fine arts and is taking a medical illustration course at Rochester. The youngest child, James, is a high school sophomore. The Ashleys's home is 22 Lynacres, Fayetteville.

James E. Keister

**James E. Keister, E.E. '35,** was named manager of engineering of the newly formed commercial equipment department, Electronics Division, General Electric Co., Syracuse. He has been with General Electric since 1935 and manager of semiconductor engineering since 1952. Keister and Mrs. Keister (Ida MacLeod '32) live on River Road, R.D. 3, Baldwinsville.

**Edgar H. Bleckwell M.E. '33,** was appointed production manager of nylon manufacturing for E. I. du Pont de Nemours & Co., Wilmington, Del., October 6. Bleckwell, who resides at 603 Greenfield Place, Bellevue Manor, Wilmington 3, Del., has been with duPont since 1934.

Lieutenant **Richard H. Hinz, B.C.E. '51,** is an observer with the Air Force in Japan. His address is 37th Air Reserve Squadron, APO 710, c/o PM, San Francisco, Cal.

**Forest E. Blair, B.C.E. '51,** married Maray K. Ingraham of Long Meadow, Mass., last September. The Blairs live on Rt. 2, O'Fallon, Ill.

**Thomas W. Jones, C.E. '51,** married **Nancy Van Scott '53,** June 27, 1953. Their address is Box 472, 502 Air Defense Sqd., Youngstown Minicipal Airport, Vienna, Ohio.


THE NEW CAMPUS SHOPPING CENTER

**Sports Goods—Men's Dept.**
Equipment and clothing for all campus sports. Haberdashery and accessories for men.

**Co-ed Shop**
Cosmetics, nylons, anklets, handbags, slickers, rain hats, uniforms, Cornell T shirts & jackets.

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Cigarettes, cigars, pipes, tobaccos, candies, smoker's accessories, Midnight snack supplies, Sealtest ice cream, magazines & pocket books.

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The largest and most complete selection of photographic equipment and supplies of any college store in the country.

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Cornell gifts and souvenirs, radios, phonographs, jewelry, electrical appliances, and hundreds of other items.

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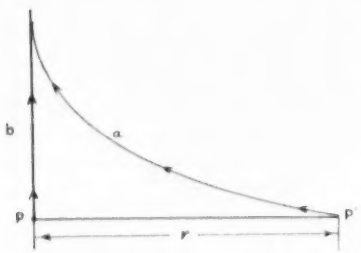
# This Month's Brain Teasers

by BOB KANTOR

The CORNELL ENGINEER is offering three dollars to the first person who mails us the correct answers to all of the problems listed below. In general, the puzzles require very little paper work but a good deal of ingenuity.

1. A ship is traveling due north at a constant rate b. The instant the ship reaches point P a submarine lying at point P' (PP'=r) sends a homing torpedo skimming along




the surface of the water toward the ship. The torpedo's direction is such that at every instant along its path its velocity vector is always directed at the ship. If the torpedo has a constant speed, a, how long will it take the torpedo to hit the ship. Express the answer in terms of a, b, and r.

2. The following is a problem in addition. However, instead of numbers, letters have been used, each letter always standing for one and only one number. No two letters can stand for the same number. When you have replaced each letter with its appropriate number, you will have a correct addition.

S E N D
M O R E
M O N E Y

3. What is the next number in the following series?

50, 54, 49, 59, 42, 70, 5, ?

---

Two mistakes turned up in the December column. The first problem should have read: Find the price of eggs if two *less* eggs, etc. (It was double-talk after all.) Because of this error the problem will not be counted. The second error was the answer to the card problem of the October issue. The probability of success is 0.6321 and not 0.6365. Since no one has submitted correct solutions to either the November or December puzzles, we will hold off printing their solutions just one more month. Here are the October problems solved.

1.

$$\log 15 = \log 10 - \log 2 + \log 3$$
$$= 1 - \log 2 + \log 3$$
$$\log 864 = \log 32 + \log 27$$
$$\log 648 = 2.81157, \quad \log 864 = 2.9361,$$
$$81 = 3^4, \quad 8 = 2^3, \quad 32 = 2^5, \quad 27 = 3^3$$
$$2.81157 = 4\log + 3\log 2$$
$$2.9361 = 5\log 2 + 3\log 3$$

We can solve the equations above simultaniously for log 2 and log 3 and thereby find log 15.

The solution to the next problem is:

$$\sqrt{2}^{\sqrt{2}^{\sqrt{2}^{\cdots}}}$$

Call the square root of two the base, and the rest the exponent, x. Then:

$$\sqrt{2}^{X} = Y$$

However, x=y, since an infinite number less one of the square roots of two is the same as an infinite number of square roots of two.

$$\sqrt{2}^{Y} = Y$$

and y=2 by inspection.

The monkey problem was essentially a problem of unraveling that lengthy chronological account in the fifth sentence.

a=uncle's age in years
b=monkey's age years
1) $a = 2(b - k_1)$
2) $a - k_1 = \frac{1}{2}(b + k_2)$
3) $b + k_2 = (a - k_3)$
4) $a - k_3 = 3(b - k_3)$
5) $a + b = 4$

Solve Equation 4 for $k_3$ in terms of a and b. Substituting this value of K, in Equation 3 we can find the value of $k_2$ in terms of a and b. Replacing $k_2$ with this result in the second equation gives us $k_1$, and plugging in this expression for $k_1$ in Equation 1, results in an equation solely in terms of a and b. Solving this last equation simultaneously with Equation 5, we find that:

a=2½ years
b=1½ years

Since the monkey and his uncle are suspended at equal distances from the floor, they weigh the same, 2½ lbs.

If $W_1$=weight of rope
$W_2$=weight of monkey
$W_3$=weight of uncle

Then:

$$W_1 + W_3 = 3/2(W_3 + W_2 - W_1)$$
$$W_1 = \tfrac{1}{2} W_3$$

$$\text{length of rope} = \frac{\text{weight of rope}}{\text{density}}$$

$$= \frac{5/4 \text{ lbs.}}{1/4 \text{ lb/ft.}}$$
$$= 5 \text{ lbs.}$$

# NO "ROBOT ENGINEERS" AT REPUBLIC AVIATION

## EMPHASIS ON THE INDIVIDUAL . . . CHALLENGE AND DIVERSITY OF ASSIGNMENTS BRING OUT THE CREATIVE SIDE OF THE ENGINEER

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No top-level conference . . . it's typical of the interchange of ideas, the freedom of expression emphasized at Republic.

For the Republic engineer is not . . . and never has been . . . a robot in his thinking or way of working. We consider him a creative engineer. We give him the challenge of stimulating assignments in advanced design, the leadership of top men to learn from, and strong incentive and rewards for his efforts.

This is the approach to engineering that Republic has successfully followed for over 22 years, and it has paid off for everyone concerned. It has made us a leader and top producer in the aircraft industry. It has provided stability, genuine opportunity, and top salaries for our engineers.

Yes, there's room to grow at Republic for men who have what it takes to keep up with our pace.

And, you'll enjoy the good living on Long Island, Playground of the East, with its year-round sports facilities — ranging from tennis to sailing to skiing. New York City, with its unparalleled cultural and entertainment facilities, is less than an hour's leisurely drive.

*For further information concerning our training programs, which prepare graduate engineers for positions in aircraft engineering or manufacturing supervision, please write directly to your special Republic representative, Mr. Charles J. Ketson, Employment Manager.*

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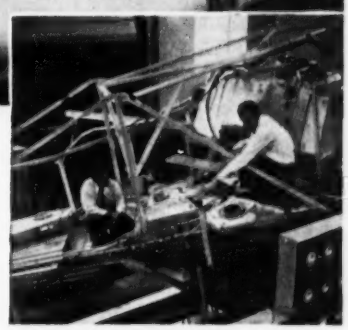
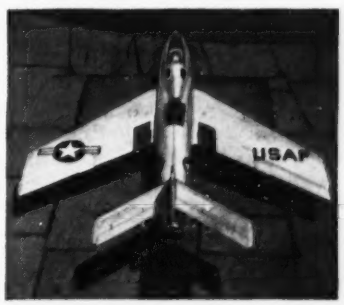


Flying fuel jig developed in Republic's laboratories to simulate actual conditions of in-flight refueling.

Cornell Alumni, Howard Smith, Engineering Trainee; Gabriel V. Pesce, Research Engineer; Robert Heider, Research Engineer, compare notes at Republic.

Republic's new F-84F Thunderstreak.



# AT YOUR SERVICE

Approximately 80 students will be selected by the Atomic Energy Commission's Admissions Committee to attend the September, 1954, session of Oak Ridge School of Reactor Technology. Students eligible for the 50-week graduate course must hold a bachelor's degree or higher in chemistry, engineering, metallurgy, physics, or engineering-physics. The school is a part of Oak Ridge National Laboratory which is operated by Union Carbide and Carbon Corporation for the Atomic Energy Commission. It is one of the largest laboratories in the world, and is concerned with research and development in nearly all phases of nuclear science and technology.

ORSORT's curriculum is geared to the advanced student in science. The scope of the School's curriculum is indicated by its overall objective: "The Oak Ridge School of Reactor Technology was organized to educate selected students in reactor technology and in the application of basic sciences, applied sciences, and modern engineering techniques to the design and development of reactor systems and their components."

The faculty includes many distinguished technicians and researchers. In addition, staff members of the Oak Ridge National Laboratory instruct small student sections and conduct lecture classes.

Many of the leading industries, seeing the possibilities for peacetime application of reactor technology, are sponsoring students. Forty-eight members of the present class are sponsored students who remain on the payroll of their respective companies during the training period. The remaining members of the class, recent college graduates, are paid a monthly salary by Union Carbide and Carbon Corporation. ORSORT has no tuition charge for the 50-week training session.

The curriculum will include such subjects as the following, as they apply to reactors: analysis and mathematics, chemistry and chemical technology, engineering, nuclear physics, and experimental physics. The coming term will be the fifth formal session.

Further information and application forms may be obtained from the Oak Ridge School of Reactor Technology, P.O. Box P, Oak Ridge, Tennessee.

## New Scholarships

Twenty new four-year college scholarships will be awarded in 1954 by the Lockheed Leadership Fund in a continuing program to interest talented young Americans in seeking careers in engineering and industry. All tuition and fees for four years, plus $500 per year for normal personal expenses are provided by each scholarship for students meeting all requirements. In addition, $500 is granted each participating school as a non-restricted gift for administrative purposes.

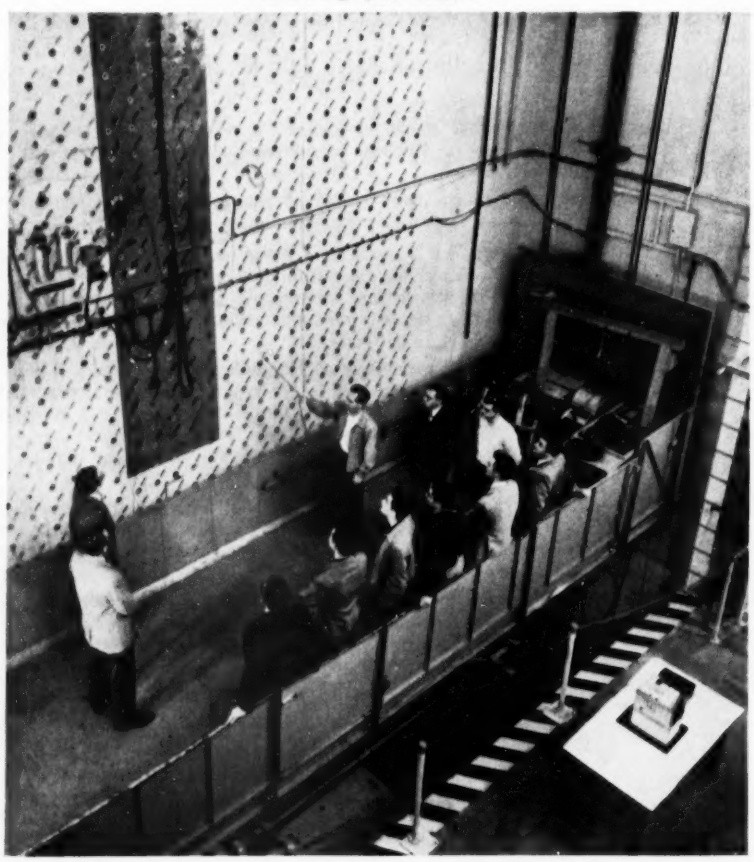
Good academic standing is only one requirement for winning one of the scholarships. Sponsors consider leadership and character equally important qualifications. Judging will be done by committees at participating schools.

During 1954 the Lockheed Leadership Fund will provide 10 undergraduate scholarships in engineering, plus 5 scholarships in other fields of study applicable to the aircraft industry. Children of Lockheed employees will be considered for 5 other scholarships in a later competition.

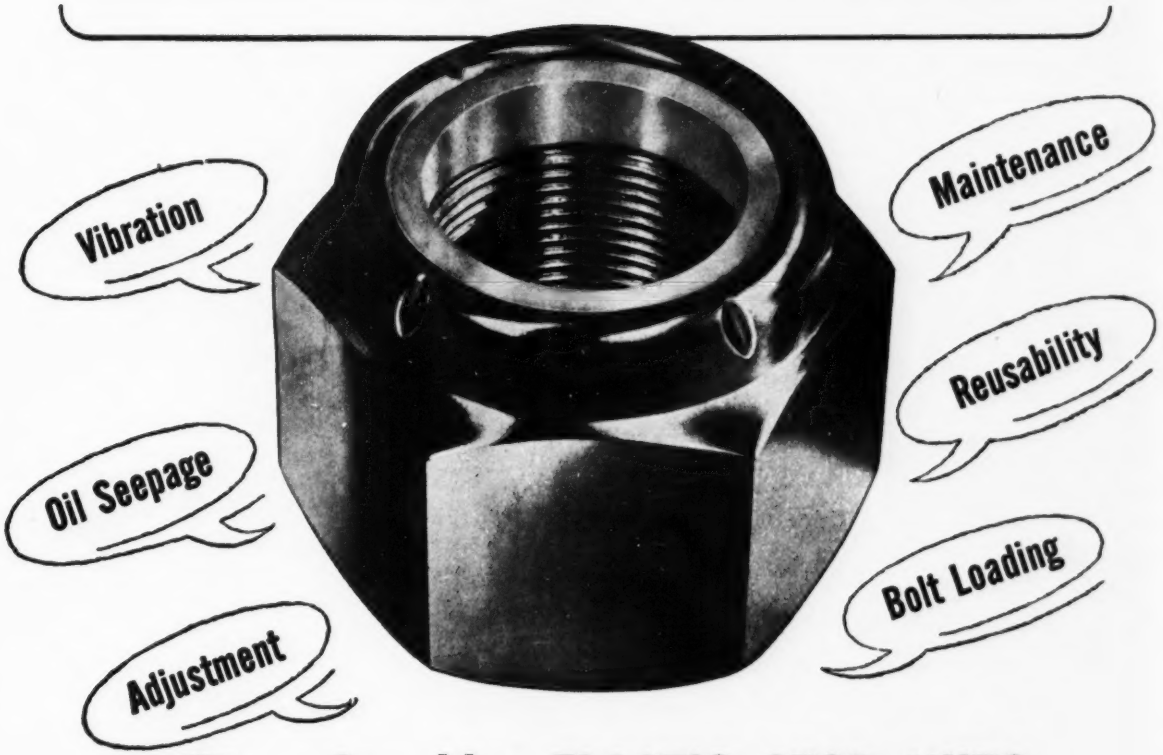
Scholarships in engineering will be awarded next year by committees at Massachusetts Institute of Technology, Carnegie Institute of Technology, North Carolina State College of Agriculture and Engineering, Renssalaer Polytechnic Institute, University of Michigan, Georgia Institute of Technology, Cornell University, Purdue University and Stanford University.

Applicants for any of the Lockheed Leadership Fund scholarships should write to the director of admissions of the university concerned to obtain application forms.

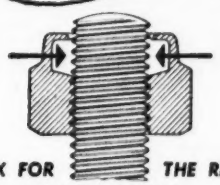
**Students of the Oak Ridge School of Reactor Technology receive instruction on a uranium graphite reactor.**



# Whenever fastening problems arise...




## Consider ELASTIC STOP NUTS



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It is threadless and resilient. Every bolt impresses (but does not cut) its full thread contact in the Red Elastic Collar to fully grip the bolt threads. In addition, this threading action properly seats the metal threads—and eliminates axial play between bolt and nut threads. All Elastic Stop Nuts—regardless of type or size—lock in position anywhere on a bolt or stud, maintain accurate adjustments and seal against liquid seepage. Vibration, impact or stress reversal does not disturb prestressed or positioned settings.

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ESNA has long been known as "design headquarters" for self-locking fasteners. Accepted by Army, Navy and Air Force, virtually every aircraft built in the past decade has been Elastic Stop Nut-equipped. On the railroads, in the oil fields, on automobiles and construction equipment, Elastic Stop Nuts manufactured to exacting quality control standards, are doing specialized jobs every day.

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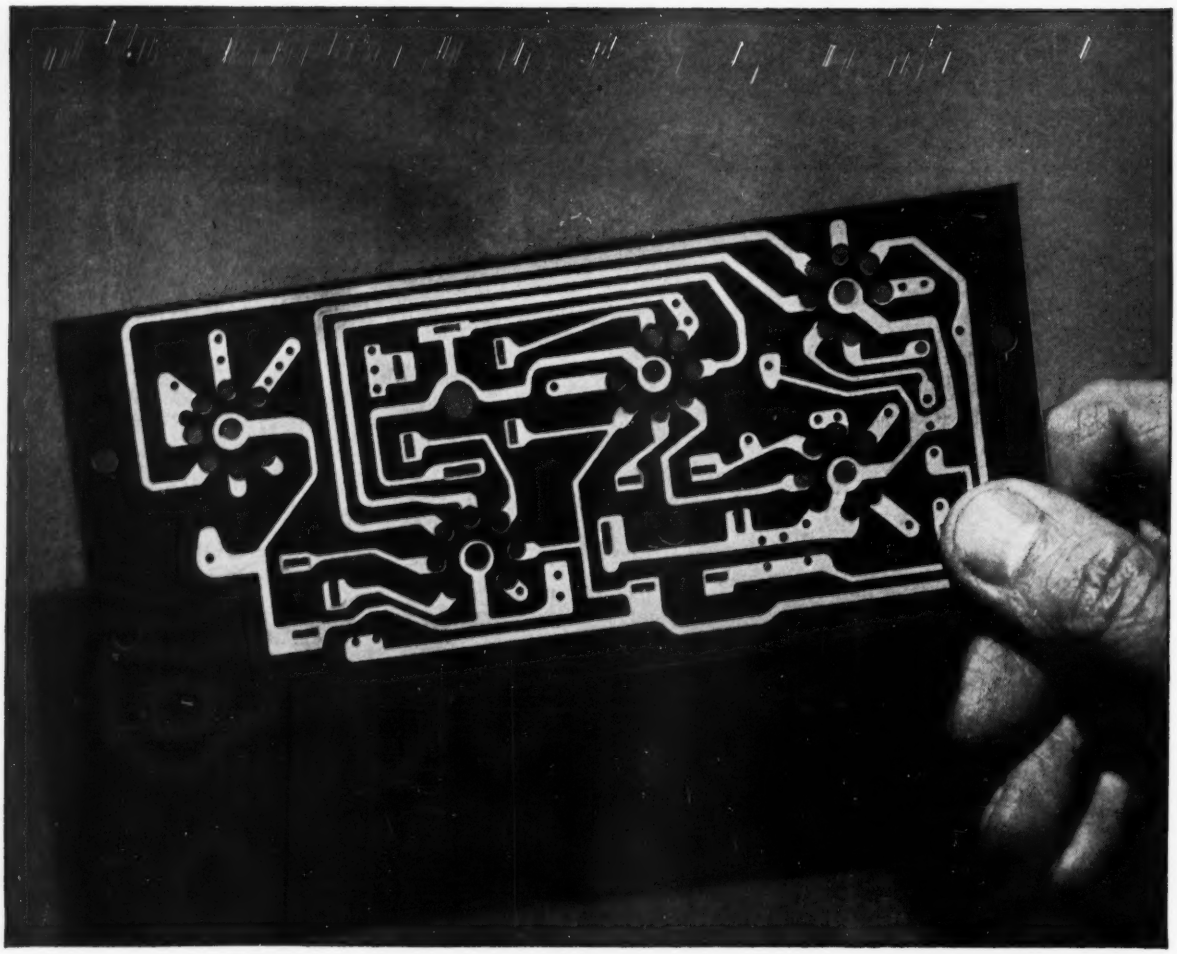
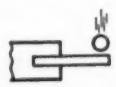


# Pattern of things to come

**IN ADDITION TO THE PROPERTIES ALREADY MENTIONED IN THE ADVERTISEMENT, SYNTHANE HAS**

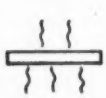


**1. Impact strength.** Synthane stands up in mechanical applications where jolts, jars and light shock loads are common. It does not splinter or break readily; will not delaminate.

**2. Tensile strength.** Synthane is strong in tension and compression.

**3. Light weight.** Synthane has approximately half the weight of aluminum.

**4. Flexural strength.** Synthane is suitable for jobs where deflexion, torsion and vibration are present. It has excellent fatigue resistance.



**5. Stable Over Wide Temperature Range.** Synthane is thermosetting; does not flow as temperature rises, has a low coefficient of thermal expansion.

Here is one of the brightest ideas in electronics—and one of the materials which helped make it possible. The idea is the printed circuit; the material is a laminated plastic called *Synthane*.

For years radio sets were put together by laboriously soldering a forest of wires to terminals. It was a time-consuming and expensive operation. If one connection proved faulty, the whole assembly had to be rechecked.

Then someone came up with the idea of *printing* the circuit with an acid-resisting ink on foil bonded to a base—and etching away the metal not needed. It would be quick, easy and error-proof—if the right base material could be found.

Among many tested, *Synthane* was one sheet material selected. Synthane has the necessary strength, low moisture absorption, is an excellent insulator and can be punched easily. It bonds securely to metal foil and withstands the etching acid used to remove the excess metal.

The printed circuit is still in development—but it has zoomed into favor for radio, TV, hearing aids, and many other electronic devices. There are now a dozen ways to produce what are still called "printed" circuits. And Synthane is an accepted base material for every one of them.

Synthane laminated plastics are available in a variety of grades and colors—in sheets, rods, tubes, and fabricated parts. You are invited to write for information to Synthane Corporation, 13 River Road, Oaks, Pa.

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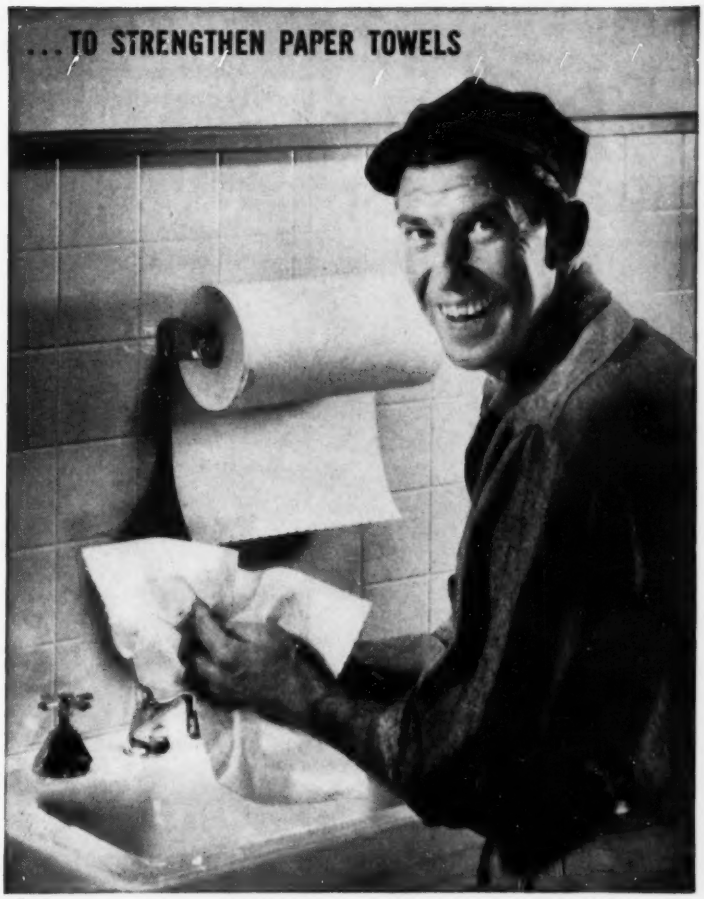
SYNTHANE
LAMINATED PLASTICS

# HOW HERCULES HELPS...

Hercules' business today helps almost everyone's business. It embraces the production of synthetic resins, cellulose products, chemical cotton, terpene chemicals, rosin and rosin derivatives, chlorinated products, and many other chemical processing materials—as well as explosives. Through close cooperative research with its customers, Hercules has helped improve the processing or performance of many products.

## ...TO STRENGTHEN PAPER TOWELS



Paper towels absorb more moisture without falling apart when Hercules Kymene® resins are added in manufacture. These resins, a few of many of Hercules' varied papermaking chemicals, help improve many other types of wet-strength papers and paperboard, including map paper, V-board, and bag papers.

## ...TO GREASEPROOF FLOOR TILE

Vinyl and asphalt-type floor tiles are processed with Neolyn® or Mastolyn® resins to give them "built-in" resistance to both grease and alkalies, while lowering manufacturing costs.

## ...TO IMPROVE AUTOMOBILE FINISHES

Lacquer made with nitrocellulose and other Hercules ingredients gives more and more cars, trucks, and buses their lustrous, longer-lasting beauty. No other finish dries so fast.

HERCULES

*HERCULES POWDER COMPANY Wilmington 99, Delaware*
*Sales Offices in Principal Cities*

EC54-2

To be a successful engineer, above all you must know how to cut costs

# SIMPLE DESIGN CHANGE TO STEEL CUTS COST FROM $1.15 TO 31¢

BEFORE any product design is accepted, the manufacturer asks, "Can it be built for less money?" Unless your designs pass this test they are likely to be rejected.

Knowing how to use welded steel gives you the advantage in developing any product for lowest cost manufacture. That's because steel is three times stronger than gray iron, two and one half times as rigid, and costs only a third as much per pound. Therefore, where stiffness or rigidity is a factor in a design, less than half the material is necessary.

Here, for example, is how one resourceful engineer put these qualities to work:

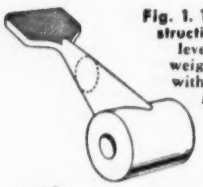


**Fig. 1. Traditional Construction.** Machine foot-lever, 10 inches long, weighs 6 pounds. Cost with broached keyway is $1.15.

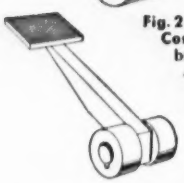


**Fig. 2. Simple Steel Design Costs 41% Less.** Can be built by the shop with only saw and shears. Weighs 2.7 pounds. Costs 68¢ complete with keyway.

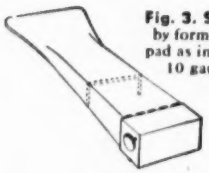


**Fig. 3. Saves 53% Cost** by forming lever arm and pad as integral piece from 10 gauge metal. Weighs 2.5 pounds. Costs 54¢.

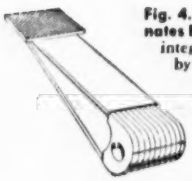


**Fig. 4. Saves 73%, Eliminates Broaching.** Hub with integral key is produced by stacking stampings in assembly. Arm is 10 gauge, brake formed and welded to hub. Cost is only 31¢. Weighs 2.2 pounds.

Back up your engineering training with latest information on welded steel construction. Bulletins and handbooks are available to engineering students by writing

**THE LINCOLN ELECTRIC COMPANY**
**Cleveland 17, Ohio**
**THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT**

*(Continued from page 2)*

Two new procedures are being introduced to improve the billing clerk's job, which at the present time is relatively inefficient. As mentioned, this clerk not only has to calculate the bills but also assigns work to the service men. This would not be too bad except for the fact that the bills are figured in longhand, which is a long tedious process and admits mistakes. To eliminate this condition a new computing machine is being purchased to replace the present billing machine. This new machine will figure the bills automatically as well as print the required information on the bills. Thus, the billing clerk can spend more time on handling complaints and give more attention to the service men.

The time now spent on the other phase of this position, the assignment of service men, is inefficiently used. As pointed out above, the billing clerk has to assign men to re-read the "skips" on which no postcard is received. At the present time, as a house is skipped the reader folds the page of the reading book and when a meter book is completed the billing clerk must go through it and write out an inspection slip for each "skip." These soon become quite a formidable pile of loose papers and confusion reigns.

To remedy this situation the water office is adopting a new style of reading book which has detachable pages in the front for "skips." Under the new system, as a house is skipped the reader notes the address and other pertinate information on this sheet in the front of the book. At the end of the day this sheet is detached and handed to the billing clerk and thus all of the "skips" of one book are in one place. As the postcards come in, the consumption can be noted on this sheet, and when it is time for the service men to check the "skips," this one sheet avoids the necessity of having to write out slips for each missed reading. These two procedure changes will both be time-savers.

partners in creating

● ALBANENE,* a K&E product, is the preferred tracing paper in thousands of drafting rooms. It is transparentized, not with messy oils that leak, but with a special synthetic transparentizer developed by K&E. ALBANENE does not turn brittle or lose its transparency with time. After years it is as good as new. *Trade Mark®

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K+E
*Drafting, Reproduction and Surveying Equipment and Materials, Slide Rules, Measuring Tapes.*

# Richard J. Conway, Lehigh '51, selects Manufacturing Engineering at Worthington

**RICHARD CONWAY** checks cutting tool with machinist before milling a pump casing.

After completing his general training which brought him in contact with all departments, Richard J. Conway decided that manufacturing engineering was his field. He says, "I chose the Manufacturing Engineering Department after completing my general training at Worthington because as a graduate in Industrial Engineering I can learn the practical aspects of my field while applying theory I learned in college.

"The personnel of this department work together as a team toward the solution of the numerous problems which arise daily. We have the cooperation of all other departments in the corporation in getting the necessary facts pertinent to the solution of these problems. In the course of our day it may be necessary for us to meet the Plant Manager, Chief Engineer, Comptroller, several department heads, clerks, foremen, machinists and many others throughout the company.

"I have contributed to the solution of many problems handled by this department including metal spraying, machining procedures, purchasing new equipment and designating proper dimensions to obtain desired fits between mating parts.

"I enjoy my work because I'm doing the work I want and my formal education is being supplemented with practical knowledge gained from the tremendous wealth of knowledge available to me at Worthington. I know from personal contact with many other departments in the Corporation that Worthington can and will find their young engineers a spot which will give them the same opportunities as have been afforded me."

When you're thinking of a good job, think *high*—think *Worthington.*

***FOR ADDITIONAL INFORMATION,*** see your College Placement Bureau or write to the Personnel and Training Department, Worthington Corporation, Harrison, N. J.

**WORTHINGTON**

The Sign of Value Around the World

# COLLEGE NEWS

On Friday, January 22, students and faculty celebrated the opening of the new student lounge in the basement of Sibly Dome. The Cayuga Waiters sang several numbers for the engineers at the grand opening.

The lounge will serve as a place for engineers to relax between classes, and as a meeting place for undergraduate societies. The lounge contains a kitchen, coke room, coat room, and a large main room with excellent lighting and ventilation. The room has all new furniture, new floor, and sound-proof ceiling.

**Front section of the new engineers' lounge. A long-awaited addition to the engineer's life, the new lounge offers these students a relaxing "dead hour."**

## IRE Hears Dr. Albert Rose

Albert Rose, of the RCA Laboratories, addressed a public meeting of the Ithaca Section of the Institute of Radio Engineers Friday, January 22 in the main lecture room at Franklin Hall at Cornell. His topic was "Photoconductivity" and he demonstrated a recent version of the Vidicon, a photo-conductive pickup tube.

Dr. Rose joined the RCA Laboratories in 1935 after receiving his Ph.D. degree from Cornell. His primary interest since then has been research on improved television pickup tubes. His work, principally the development of the image orthicon, has made it possible to use television cameras outside the studios, such as at sports events.

In recognition of his achievements, Dr. Rose has received awards from the Institute of Radio Engineers, the Television Broadcasters Association, and the Society of Motion Picture Engineers.

## Professor Shaw Lectures At Talon, Inc.

Prof. R. William Shaw, chairman of the Department of Astronomy at Cornell, was guest lecturer before the Foremen's Club of Talon, Inc., at Meadville, Pa., on Tuesday, Jan. 26.

The occasion was the annual father and son night of the club with approximately 200 present to hear an illustrated talk on "Our Neighbor Worlds."

Professor Shaw toured two of the seven plants of Talon, Inc., located at Meadville.

## ASCE Meeting Features M. D. Morris

The construction of a mammoth iron mining project in Venezuela, the Orinoco Mining Company's Cerro Bolivar project, was described in a talk and movie at Cornell on Feb. 16.

The speaker was M. D. Morris, a Cornell alumnus and consulting engineer with the Betchel International Corporation, contracting firm for the project. The Orinoco Mining Company is a subsidiary of U.S. Steel.

The Ithaca section of the American Society of Civil Engineers planned the program as part of its monthly meeting; the public was invited.

The Cerro Bolivar deposits were first identified through aerial photographs taken by the Aerial Photographic Studies Center at Cornell. The area was then prospected on foot and is believed comparable to the Mesabi Range in Minnesota. The project includes construction of mines, railroads, docks and shipping facilities.

## New C.A.L. Professorship Goes to Dr. Kac

Creation of a Cornell Aeronautical Laboratory Professorship and appointment of Dr. Mark Kac of the Cornell mathematics staff as first incumbent were announced January 22 at the University.

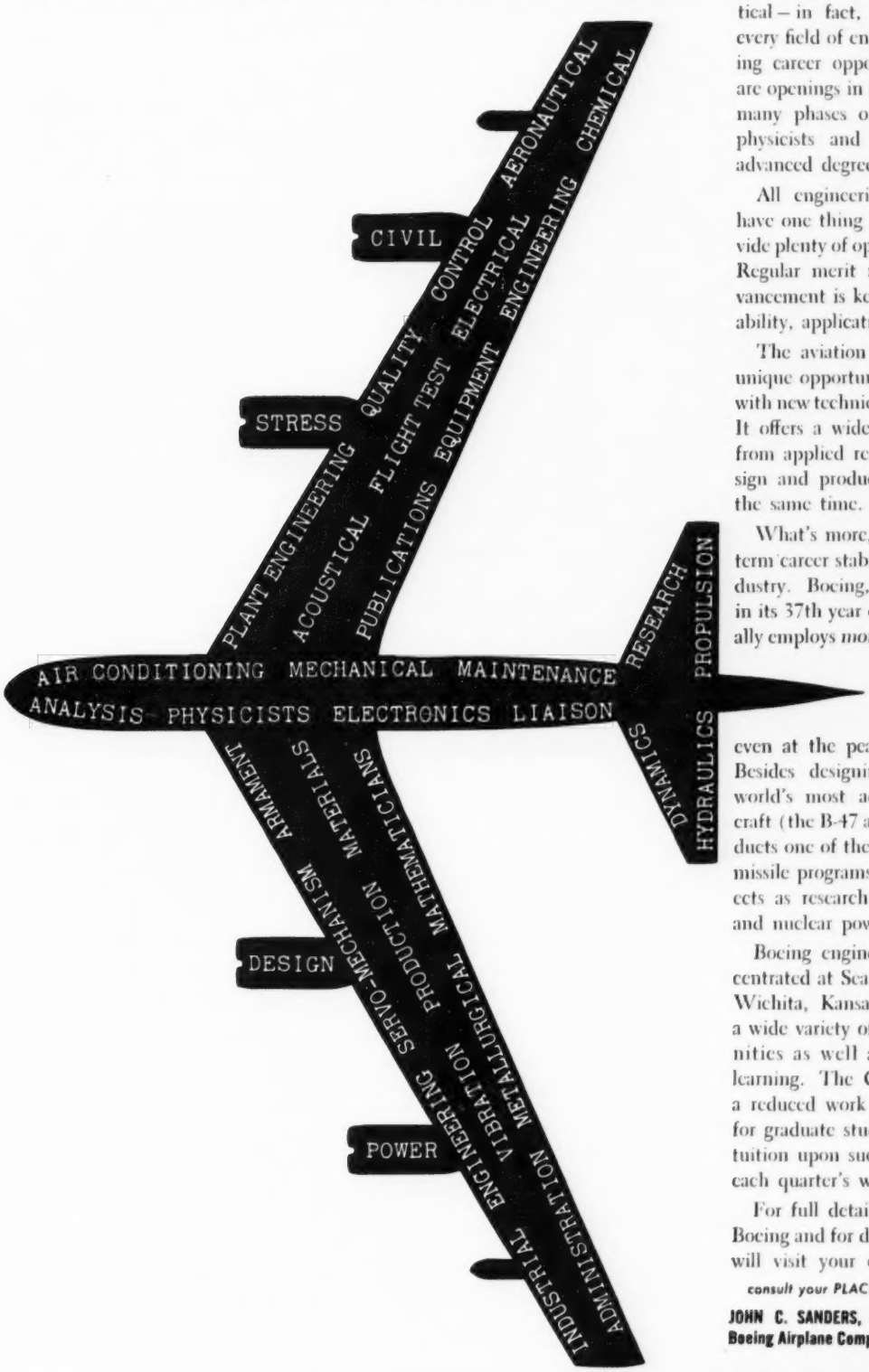
Dr. Theodore P. Wright, president of Cornell Aeronautical Laboratory, Inc., described the chair as another step toward closer educational ties between the research laboratory in Buffalo and the Cornell campus here.

For some time the laboratory has supported a program of graduate fellowships at the campus, employed students in summer jobs at Buffalo, and retained Cornell faculty members as consultants.

Dr. Wright said the chair may be rotated among members of the Cornell faculty. The incumbent will spend about a month of the year at

(*Continued on page* 42)

# Engineers of virtually EVERY type are needed on the Boeing team




Mechanical, electrical, civil, aeronautical – in fact, graduates in virtually every field of engineering–find rewarding career opportunities here. There are openings in design, research, in the many phases of production, and for physicists and mathematicians with advanced degrees.

All engineering careers at Boeing have one thing in common: they provide plenty of opportunity to get ahead. Regular merit reviews are held. Advancement is keyed to your individual ability, application and initiative.

The aviation industry offers you a unique opportunity to gain experience with new techniques and new materials. It offers a wide range of application, from applied research, to product design and production, all going on at the same time.

What's more, you can expect long-term career stability in the aviation industry. Boeing, for instance, is now in its 37th year of operation, and actually employs *more* engineers today than even at the peak of World War II. Besides designing and building the world's most advanced multi-jet aircraft (the B-47 and B-52), Boeing conducts one of the nation's major guided missile programs, and such other projects as research on supersonic flight, and nuclear power for aircraft.

Boeing engineering activity is concentrated at Seattle, Washington, and Wichita, Kansas – communities with a wide variety of recreational opportunities as well as schools of higher learning. The Company will arrange a reduced work week to permit time for graduate study and will reimburse tuition upon successful completion of each quarter's work.

For full details on opportunities at Boeing and for dates when interviewers will visit your campus,

*consult your PLACEMENT OFFICE, or write:*

**JOHN C. SANDERS, Staff Engineer – Personnel**
**Boeing Airplane Company, Seattle 14, Washington**

**BOEING**

(*Continued rfom page* 40)
the laboratory, the remainder of the time in teaching and research on the campus.

C.A.L., a self-sustaining subsidiary of the university, engages in military and industrial research. Last year it handled contracts with a total value of $9,200,000.

Dr. Kac, who has been at Cornell since 1939, has appointments in the Department of Mathematics and Engineering Physics.

He held a Guggenheim Fellowship in 1946-47 and has worked at the Institute for Advanced Study, Princeton, N.J. In 1950 he was awarded the Chauvenet Prize given by the Mathematical Association of America for a noteworthy paper by a young mathematician.

Dr. Kac received the Ph.D. degree from Johns Casimir University, Poland, in 1937 and spent a year at Johns Hopkins University before joining the Cornell faculty. He has been an American citizen since 1943.

## Director Loberg Receives ASME Position

Prof. Harry J. Loberg, Director of the Sibley School of Mechanical Engineering at Cornell, will serve as chairman of the executive committee of the Materials Handling Division, American Society of Mechanical Engineers, for 1954.

This Division has 2700 members and will sponsor four meetings during the year in Pittsburgh, Mexico City, Milwaukee and New York City.

On January 7-8 Professor Loberg attended the Professional Divisions Executives' Conference, ASME, at the General Electric Company's Knolls Research Laboratory, Schenectady. He represented the Materials Handling Division as chairman, and the Safety Division as secretary of the Executive Committee.

## Mr. Walker L. Cisler Speaks On Nuclear Power

Walker L. Cisler, president and director of Detroit Edison, addressed the 57th annual luncheon of the Cornell Women's Club of New York, Saturday, Febrbuary 27th at the Essex House. Following his discussion of "Nuclear Power for Peacetime Purposes," Mr. Cisler was interviewed by Tex McCrary and Jinx Falkenburg. The program came as a climax to National Engineer's Week (February 21-27). Observance of National Engineer's Week, endorsed by President Eisenhower, is designed "to remind our citizens once more of the great service performed by America's engineers."

Mr. Cisler, an alumnus and trustee of Cornell University, became president of Detroit Edison in 1951. He has been actively engaged in atomic energy development at Detroit Edison since the end of World War II. Mr. Cisler served as executive secretary of the AEC Industrial Advisory group (1947-1948). He has continually supported the company role in the Nuclear Power Development Project carried on with cooperation of Dow Chemical Company.

## Professor Belcher to Lead Project in Burma

Prof. Donald J. Belcher, director of the Cornell Center for Aerial Photographic Studies, has departed for Rangoon, Burma, to initiate a year-long program of aerial photographic training for Burmese nationals.

With the support of the U.S. Foreign Operations Administration, the Burmese government has contracted with Cornell to train Burmese specialists to use aerial photographs in the fields of forestry, soils, urban and land planning, geology and agriculture.

Dr. Ta Liang, of the Center's staff, will be field director in Burma for a major portion of the program. A visiting professor at Cornell, he served as a senior engineer with the U.S. Army during World War II and has been with the center since its inception in 1950.

Another member of the team is Prof. T. M. Bushnell of Purdue University, director of the Indiana Soils Survey, who has had wide experience in Japan and Central America. Ernest Stoeckeler, on leave from the U.S. Forest Service, will supervise the forestry division of the work.

It is expected that an urban planning specialist from the Department of Regional Planning in Cornell's College of Architecture will also join the group in Burma.

Under the direction of Professor Belcher, the Cornell center has developed pioneer methods of using, and teaching others to use, aerial photographs. Its research programs have carried staff members to virtually every part of the world.

A recent assignment took a group to Iran to assist the Iranian government in developing its water resources. Working from aerial photographs, they mapped 50 water-well sites in as many days.

In Burma, the Cornell team will work from photographs made recently in a large-scale mapping of the country.

Among forestry applications, the Burmese will learn how to use the photos to identify tree types, plan future cuttings, locate access roads, and establish reforestation practices.

A geologist will give training in reconnaissance mapping and rock identification, especially in relation to the country's natural resources. Another large segment of the instruction will be devoted to the "mapping" of soils for agricultural purposes.

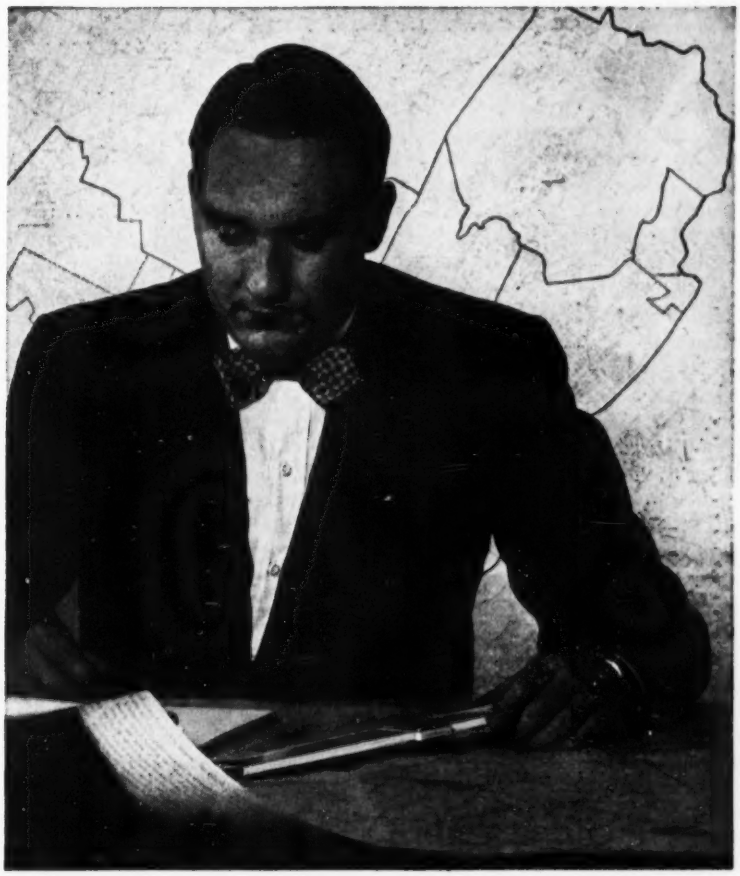
Following the work in Burma, it is anticipated that the Burmese government will send a group of the students to Cornell for advanced training in the aerial photography field.

Arrangements for the Burma assignment were initiated last August with the visit of a Burmese government representative to the campus. Negotiations were concluded last week.

In Rangoon, Professor Belcher will establish offices and complete plans for the project. Dr. Liang will join him there in early February and the other members of the team will assemble by February 15.

A CAMPUS-TO-CAREER CASE HISTORY

# A Second Education



What makes a job hold its interest? After working for three years, Wylie Borum, E. E., '50, tells us what has kept his interest alive.

(*Reading time*: 38 *seconds*)

He graduated from the University of Pennsylvania in 1950, but Wylie Borum's education still hasn't ended. His job, he explains, has become his second education. And this continuing process of learning has kept his job interesting.

Wylie's first year at Bell Telephone Company of Pennsylvania was spent as a student engineer, which he feels was not only educational but extremely worth while. For it was while he took this course that he glimpsed the complexity of the business in considerable detail. He worked in all departments – ran switchboards, climbed poles and even did a stint in the Accounting Department.

Wylie discovered that there were many spots in the telephone organization for engineers besides the General Engineering Department. Even in Accounting – which today is highly mechanized with things like Centralized Automatic Message Accounting Machines.

Training finished, Wylie was assigned to the Manual Equipment Section of the General Engineering Department. His education continued. He found out, he reports, that the dollar is an important part of engineering. In writing equipment specifications, he had to be sure of reasonable cost as well as efficient operation. There's a big difference, he discovered, in doing a theoretical job in school and doing a job in which costs are an important consideration.

Now Wylie has been promoted to the Plant Extension Engineering Group and still is learning. His present job is co-ordinating plans for replacing the last manual central office in Philadelphia with a dial system. The cost will be approximately $1,500,000.

It's a big responsibility. But the Telephone Company puts capable young men on their own quickly.

• • •

**Wylie Borum's job is with an operating company of the Bell System. But there are also job opportunities for engineers in Bell Telephone Laboratories, Western Electric, and Sandia Corporation.**

BELL TELEPHONE SYSTEM

# TECHNIBRIEFS

The XP-21 Firebird, a sleek, white, single-seater, automobile with aerodynamic styling, made its first public appearance at the GM Motorama of 1954 in the Waldorf-Astoria Hotel at New York, January 21-26.

Constructed as an experiment to study future possibilities of the gas turbine for commercial uses, the XP-21 has undergone preliminary tests since last October at Milford, Mich., and near Phoenix, Ariz.

The gas turbine car's mechanical anatomy, the reverse of conventional automobiles, includes a 35-gallon glass fiber-plastic fuel tank in the nose ahead of the driver.

Behind the driver is an integrated power "package" with an engine consisting of two mechanically independent parts called the gasifier and power sections.

The gasifier section replaces the engine and torque converter pump in a conventional automobile, while the power section replaces the torque converter turbine, transmission and rear axle gears.

The Whirlfire gasifier section is a compressor rotor and a gasifier turbine wheel, both attached to the same shaft. Air enters the compressor where it is raised to more than 3½ times atmospheric pressure before entering the engine's two combustion chambers. Kerosene is burned in these chambers, raising the gas temperature to approximately 1500 degrees Fahrenheit.

The Whirlfire engine develops 370 horsepower when the gasifier turbine is spinning at 26,000 r.p.m., and the power turbine is revolving at 13,000 r.p.m. Total weight of the engine unit, including gasifier and power sections, is only 775 pounds. Overall weight of the entire car is 2500 pounds.

## NBS Investigates Corrosion Of Metals in Soil

A recent study by the National Bureau of Standards has shown that reliable data on the corrosion of ferrous metals in soils of various types can be obtained in the laboratory in a period of six months. Usually field tests lasting 10 years or more are required. In the NBS investigation, which was conducted by W. J. Schwerdtfeger of the Bureau's corrosion laboratory, corrosion was produced in small laboratory cells by differential aeration of metal disks in contact with soil within the cells. The results for 15 different soils showed good correlation with the corrosion observed on wrought specimens in long-term exposure tests. The technique used by the Bureau should thus provide a valuable basis for predicting the service of iron and steel structures exposed to various soils.

## New Polyester Film Has Many Uses

"Mylar" is a recently developed transparent Polyester film with a wide variety of uses that includes metallic textile yarn, electrical insulation, acoustical tile, sound recording tape, liners for drums and other containers, and decorative laminations.

While Mylar resembles cellophane in appearance, that is about as far as the resemblance goes. The new film has a combination of mechanical strength, long-term resistance to heat, chemical inertness, and high dielectric strength, which makes it suitable for a series of new industrial uses, such as:

Electrical insulation: Mylar polyester film is being used by manufacturers as phase insulation and slot liners for electric motors. It is also used for insulation in capacitors.

Tapes: It makes a tough, dimensionally stable base for industrial and electrical tapes. It is especially good for sound recording tapes and for electronic computing machines.

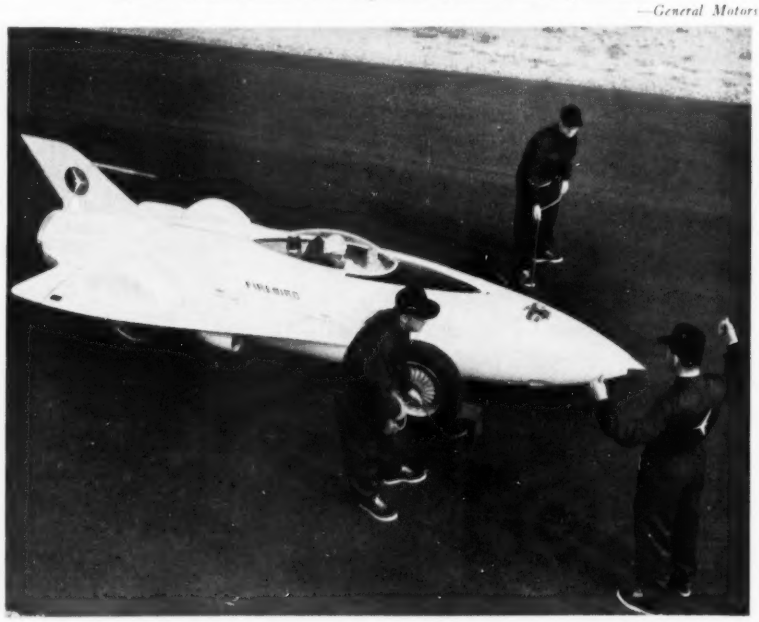
Metallic yarn: Mylar polyester film may be laminated to both sides of metal foil and slit into very narrow widths, to produce a metallic yarn that is strong and unaffected by dry-cleaning solvents or high ironing temperatures.

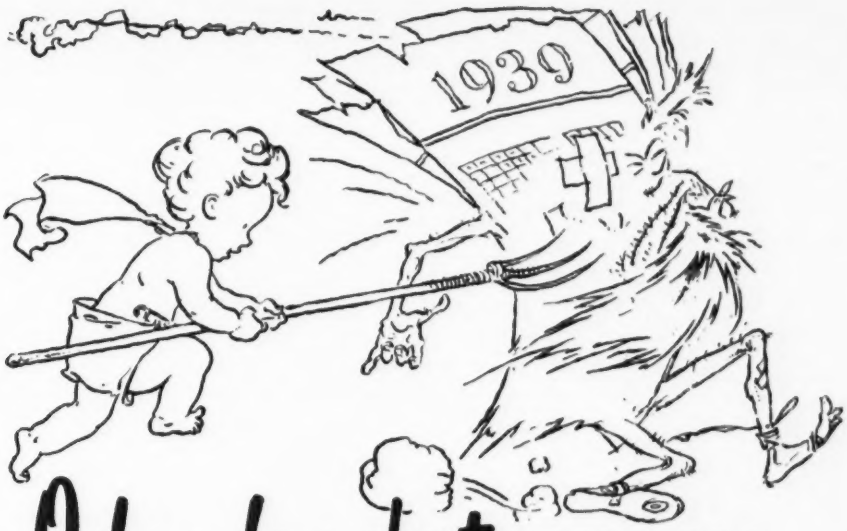
Thermal insulation: Laminated to another material, such as glass

(*Continued on page* 46)

**Driver Mauri Rose signals his crew as he prepares to test the XP-21 Firebird at the General Motors Desert Proving Ground, near Phoenix, Arizona.**

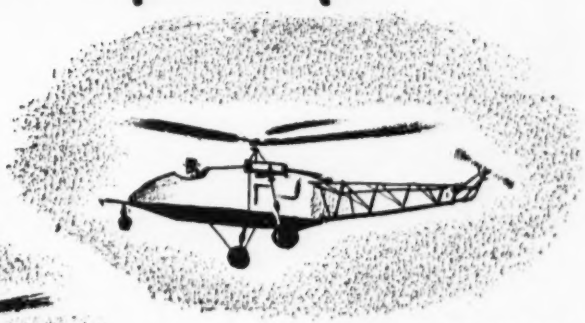
*—General Motors*





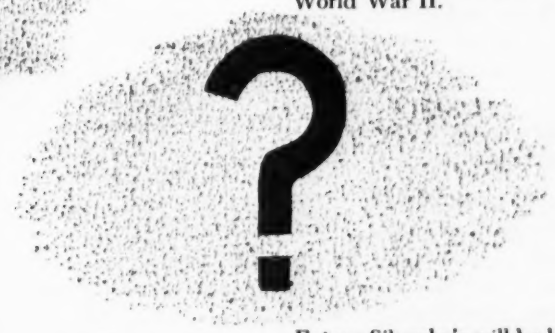

# Only a few short years ago

the helicopter was thought to be a "stunt" machine – amazing and amusing, and not particularly important. Events in Korea changed that idea – fast! This fledgling among aircraft performed "impossible" military assignments, spectacularly successful missions of mercy. Helicopters came into their own.



In 1939, the VS-300 with Igor Sikorsky at the controls made the first practical helicopter flight in the United States. Hundreds of later Sikorsky's were delivered for service in World War II.

Now in demand for hundreds of jobs, today's most versatile flying machine is the product of ceaseless testing, highest-calibre engineering, work and imagination.



Future Sikorsky's will be built by tomorrow's engineers. Perhaps *you* belong at Sikorsky where your skill and ability will be continually challenged.

You might find – in Sikorsky Aircraft's research departments, drafting rooms, engineering laboratories – a lifetime opportunity in this young, growing and most interesting field of aviation. Write today to R. C. Banks, Personnel Department.

SIKORSKY

**Sikorsky Aircraft, one of the four divisions of United Aircraft Corporation, South Avenue, Bridgeport 1, Conn.**

(*Continued from page* 44)
cloth, the moisture vaporproofness of Mylar prevents water from condensing inside the primary insulation material.

## Electronic Brain Controls New Punch Press

An automatic punch press with an electronic brain has been developed by General Electric at Syracuse, N.Y., and its techniques are being adapted to electronic equipment fabrication under a U.S. Signal Corps contract.

The machine was described as "one more step toward the automatic factory of the future" in a talk and motion picture presented at an Institute of Radio Engineers symposium on automation.

Directions are fed to the punch press by an electronic digital computer. The computer "reads" a perforated card which has information on size, number and location of the holes to be punched. The punch press automatically positions the material to be perforated and performs its punching operations within an accuracy of a few thousandths of an inch.

The automatic punch press was described as the forerunner to an assembly machine to be used in the automatic assembly system being developed for the Signal Corps. The Signal Corps support of this automatic factory program is based on the recognized need for vastly expanded electronic production to meet the anticipated demand in case of emergencies.

## Improvements Made On Hydrogen-cooled Generator

The world's first completely inner-cooled generator—described by engineers as one that will literally open a new era in the history of power generation—is ready for shipment from the East Pittsburgh plant of the Westinghouse Electric Corporation.

The new unit is rated at 100,000 kilowatts and is powerful enough to light a city the size of Nashville, Tenn.; However it is only slightly larger in physical size than the average 40,000 kilowatt machine. The new generator weighs about 350,000 pounds which is about 150,000 pounds less than the average 100,000 kilowatt unit.

The key to the increase in power rating, while the physical size is reduced, lies in a new cooling system for large turbine generators. This system is designed in such a way that the cooling agent, hydrogen gas, comes in intimate contact not only with the bare copper of the coils in the rotating part of the generator, but also with the copper coils of the stationary part of the machine. After carrying the heat away for disposal, the hydrogen is then recirculated through the machine. Up to this time the hydrogen has been able to pick up only limited amount of heat that seeped through the insulating jacket covering the copper and steel.

## Large Scale Experimental Steam Condenser Built (See frontise)

An experimental surface-type steam condenser has been built by Allis-Chalmers Manufacturing Company to accumulate heat-transfer data which are expected to lead to improved commercial design.

Outwardly of unconventional design, the unit's interior represents a typical section of tubes taken from a full-size condenser of the type and design produced by Allis-Chalmers.

The model has been designed to permit it to be adapted to various tube and baffle arrangements as well as different tube sizes and materials. Through the use of a removable type tube bundle, tests can be run which will allow the investigation of the heat transfer characteristics of a series of varied tube configurations.

The initial tests will use 280 5/8-inch diameter tubes to give a total effective surface area of 276 square feet. The surface available in this condenser will then vary as different size tubes and tube configurations are used.

It is believed to be the first time that studies on condenser tube spacing and laning, tube vibration, pressure drop through the steam space, and baffling arrangements have been made on this scale.

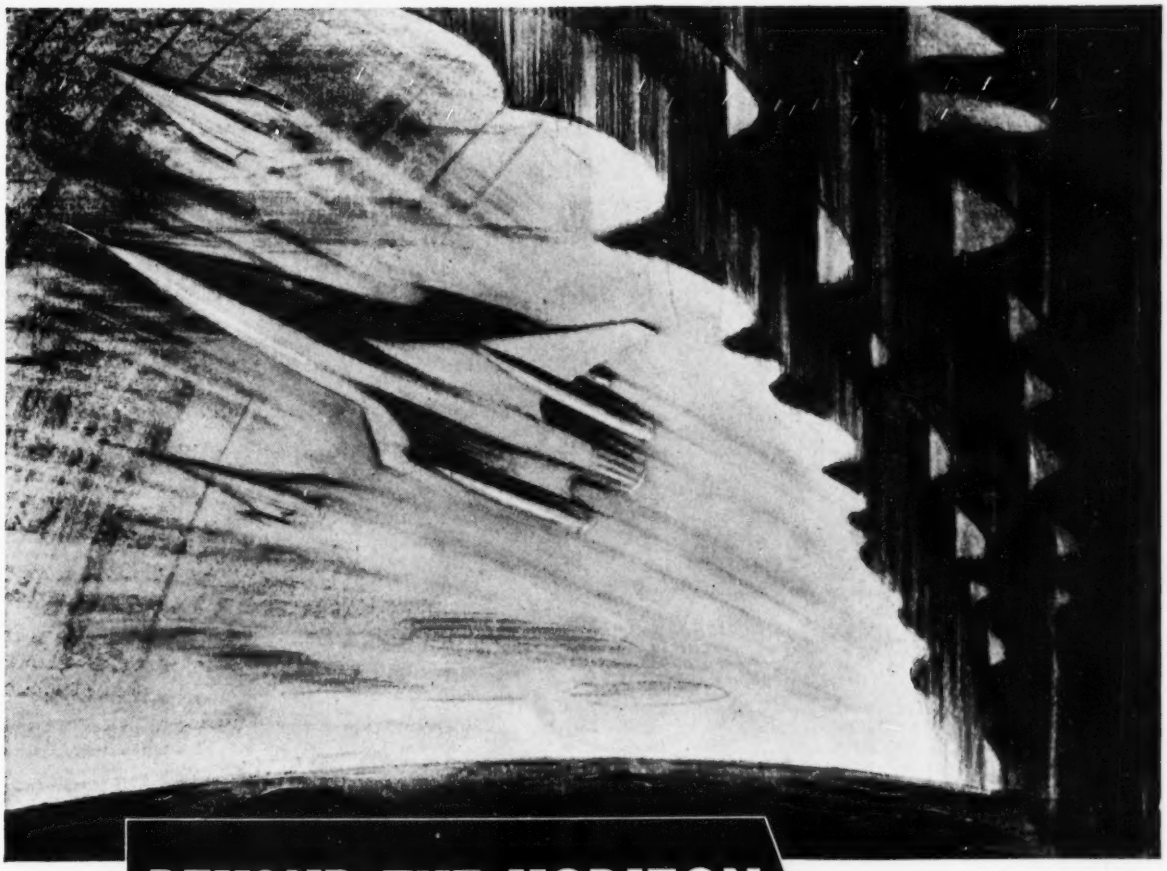
## Comfort For Airline Passengers

Passengers who have sat in airplanes waiting to take off and either sweltered or shivered, according to the weather, will find relief at the new Greater Pittsburgh Airport at Pittsburgh, Pa.

It's the only airport in the world to provide a central air-conditioning and heating system that connects by hose to standing aircraft.

Trap doors on the apron where airplanes park contain hoses for fresh air as well as gasoline and oil The hose for the air-conditioning and heating system is connected to the bottom of a plane and fresh air is pumped through the airliner's ventilation ducts as long as the craft remains in the parking area.

Constructed like a giant centipede, the supply system pipes conditioned air through underground ducts to loading planes. Housed in the basement of the airport Administration Building are 71 heating and cooling coils, 30 fans ranging from three to eight feet in height, and nine Precipitron air cleaning units. The equipment will supply 31 planes at once, in addition to conditioning the administration building itself.



## BEYOND THE HORIZON....

Progress in reaction-motor propulsion becomes possible only as the metallurgist supplies new alloys to withstand the stresses, temperatures, and corrosive attack developed by new rocket fuels.

Molybdenum additions to many alloys are known to improve strength at high temperatures. For this reason Molybdenum will be used more and more in the reaction motors of the future.

Climax furnishes authoritative engineering data on Molybdenum applications.

**Climax Molybdenum Company**
500 Fifth Avenue · New York City 36 · N.Y.

# School of Mechanical Engineering
## CLASS OF 1954

1. Redmond, R.
2. Wood, H.
3. Potter R.
4. Russel, J.
5. Berlinghof, C.
6. Scheraga, D.
7. Herr, J.
8. Roth, E.
9. Welch, R.
10. Tamarkin, J.
11. Myers, M.
12. Pechenik, S.
13. Tamarkin, J.
14. Gratz, W.
15. Stein, A.
16. Meurer, H.
17. Conway, R.
18. Olt, R.
19. McCullough, H.
20. Gold, R. E.
21. Hanna, M. A.
22. Weiss, B. L.
23. Foss, D. L.
24. Koch, D.
25. Schneider J.
26. Lankton, G.
27. Johnson, W.
28. Ragold, R.
29. Pradt, L.
30. Beishein, J.
31. Richardson, L.
32. Buhrendorf, F.
33. Swift, J.
34. Kormondy, R.
35. Cohn, H.
36. Emanuel, F.
37. Muller, D.
38. Cromwell, D.
39. Repetto, R.
40. Meyer, K.
41. Whitlock, R.
42. Juran, C.
43. Vanderhoek, R.
44. Parker, J.
45. Pfeiffer, C.
46. Bechert, T.
47. David, W.
48. Roth, W.
49. Isaacson, D.
50. Roth, C.
51. Everett, C.
52. Burdick, C.
53. Heinzman, R.
54. Donaldson, G.
55. She, B.
56. Taylor, J.
57. Canal, J.
58. Will, J.
59. Campbell, D.
60. Knauss, W.
61. Geis, J.
62. Tornberg, I.
63. Shaffer, R.
64. Ray, E.
65. Jarvis, R.
66. Leinbach, R.
67. Lyles, J.
68. Lee, R.
69. Miskell, T.
70. Angus, J.
71. McClintock, M.
72. Wambach, R.
73. Brophy, J.
74. Hopper, T.
75. Little, T.
76. Smith, H.
77. Hayden, H.
78. Hungerford, J.
79. Downey, P.
80. Hutton, H.
81. Mann, W.
82. Eskin, R.
83. Marshall, R.
84. Crook, G.
85. Dragelin, N.
86. Rutishauser, R.
87. Wiseman, J.
88. Byrne, J.
89. Leinroth, E.
90. Jessup, R.
91. Townsend, R.
92. Slater, T.
93. Zwigard, F.
94. Boehm, A.
95. Murach, J.
96. Donaldson, S.
97. Kampf, W.
98. Lautenberger, J.
99. McConnell, W.
100. Pyott, A.
101. White, N.
102. Fratt, P.
103. Grady, W.
104. George, W.
105. McCarthy, C.
106. Wechter, D.

**A MESSAGE TO COLLEGE ENGINEERING STUDENTS**

from A. C. Monteith, Vice-President in Charge of Engineering and Research, Westinghouse Electric Corporation, *Queen's University, Kingston, Ontario, 1923*

# The second most important decision in your life

Now, as you near graduation, you are about to make a decision—second in importance only to choosing your life's partner.

I'm talking, of course, about that all-important first job. Which company will it be? I wouldn't presume to answer that question for you. But I would like to emphasize the importance of this decision.

You have a lot at stake. The direction your career takes will most certainly be influenced by the company with which you cast your lot. May I offer a few personal suggestions.

Choose a company not for its bigness or smallness, but for how it will treat you as an individual. Choose it not only for its engineering activities alone, but also for how it is set up to help its engineers develop themselves professionally. Choose your company with an eye on the opportunities ahead—and an eye on the future of the company itself. Above all, select a company that has a definite program to help you determine the work for which you are best fitted.

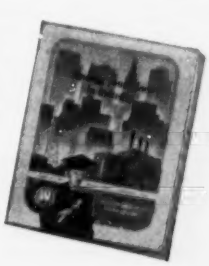
Only you can make this vital decision. Whatever it may be—good luck!

G-10275

**YOU CAN BE SURE...IF IT'S Westinghouse**

For information on career opportunities with Westinghouse, consult the Placement Officer of your university, or send for our 44-page book, *Finding Your Place in Industry.*

Write: Mr. P. B. Shiring, Regional Educational Co-ordinator, Westinghouse Electric Corporation, Ellicott Sq. Bldg., Buffalo 3, New York.



They're *easier* to handle thanks to

**S.S.WHITE FLEXIBLE SHAFTS**

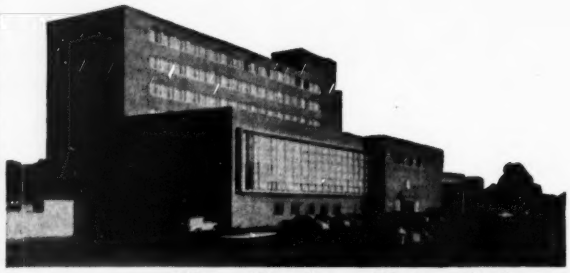
● LIGHT WEIGHT AND MOBILITY are essential features of any portable tool. That's one reason why the manufacturer of these concrete surfacers uses S.S.White flexible shafts to transmit power between the motor and the working head. As he puts it, the flexible shafts "provide flexibility of movement for the operator and eliminate the need for holding the motor unit which is the heaviest part of the equipment."

Many of the design problems you'll face after graduation will involve ways of transmitting power or control at low cost. That's why you'll want to become familiar with S.S.White flexible shafts *now*, because they are the economical solution to many of these problems.

***SEND FOR THIS FREE FLEXIBLE SHAFT BOOKLET . . .***

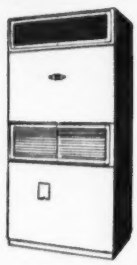
*Bulletin 5306* contains basic flexible shaft data and facts and shows how to select and apply flexible shafts. Write for a copy.

THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO. Dept. C, 10 East 40th St. NEW YORK 16, N. Y.



**New Student Union Selects Air Conditioning & Refrigeration**

FRICK



This fine building of the Indiana University Medical Center, at Indianapolis, comprises apartments, guest rooms, dining halls, shops, swimming pools, etc.

Here both air conditioning and food service loads are handled by 13 Frick refrigerating machines, and a Frick unit air conditioner. Installation by Hayes Bros., Inc., Distributors at Indianapolis and South Bend. For that important cooling job of yours, specify Frick equipment: there's nothing to compare with it. Write now for Bul. 100 on "ECLIPSE" compressors.

*The Frick Graduate Training Course in Refrigeration and Air Conditioning, operated over 30 years, offers a career in a growing industry.*

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**Wrico Lettering Set** ..... **$6.90**

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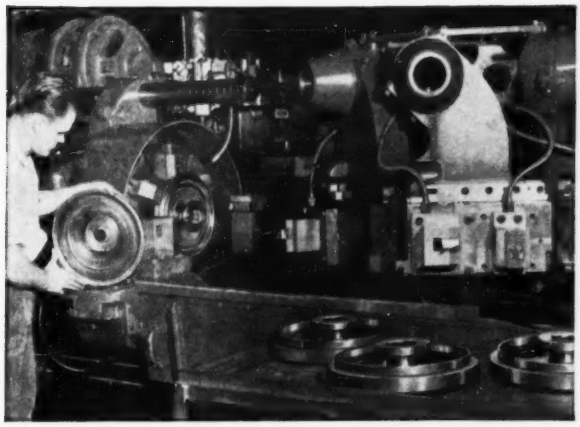
*Another page for* **YOUR BEARING NOTEBOOK**



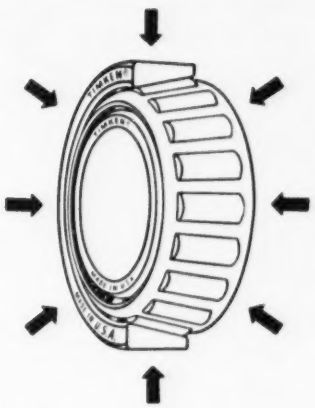
## How to speed production of high precision jet engine parts

Engineers had the problem of designing a turret lathe that would machine a stainless steel jet engine part having a very complicated shape. And the part had to be produced in volume—yet with extreme precision. Naturally, they had to be sure the lathe spindle would be held rigid. To solve their problem, they mounted the spindle and gear train on Timken® tapered roller bearings, eliminating spindle vibration and chatter, insuring high precision.

---

## Here's how TIMKEN® bearings maintain spindle rigidity

Timken bearings hold spindles in rigid alignment because line contact between rollers and races gives spindles wide, rigid support. Because the tapered design of Timken bearings lets them take radial and thrust loads in any combination, deflection is minimized, end-play and chatter eliminated. Spindles maintain their accuracy, year after year.



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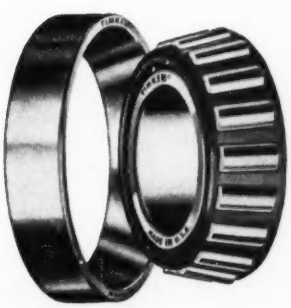


**TIMKEN**
TRADE-MARK REG. U. S. PAT. OFF.
*TAPERED ROLLER BEARINGS*

## Want to learn more about bearings or job opportunities?

Many of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings, write for the 270-page General Information Manual on Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, Ohio.

**NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◎ AND THRUST —◎— LOADS OR ANY COMBINATION ✳**

NORTH AMERICAN HAS BUILT MORE AIRPLANES THAN ANY OTHER COMPANY IN THE WORLD

# your challenge...

## build a better airplane than this!

***F-100 Super Sabre*** – designed and built by North American Aviation. America's first *true* tri-sonic fighter . . . flies faster than sound in level, operational flight. Now in priority production for the Air Force.

The plane *you* help design and develop will probably carry a designation somewhere in the mid-hundreds . . . perhaps it will be jet-powered, maybe ram-jet . . . or we will have developed a rocket propulsion system capable of sending it into the high Mach numbers. It may carry a pilot . . . it may not. But it will embody design principles, new electronic components and air artillery far advanced beyond anything now in the air.

North American Aviation, designers and builders of the world-famous F-86 *Sabre* Jet and the new ***F-100 Super Sabre,*** needs engineers with vision and imagination . . . men with a solid technical foundation who will be ready to help design and build the better aircraft of tomorrow. Other fascinating careers are also open in North American's guided missile, jet, rocket, electronic and atomic energy programs. Projects that are years ahead to keep America's security strong.

When you are prepared to enter the engineering profession, consider the well-paid career opportunities at North American. Meanwhile, write for information concerning your future in the aircraft industry.

***Contact:*** **Your College placement office or write:** ***Employment Director,***

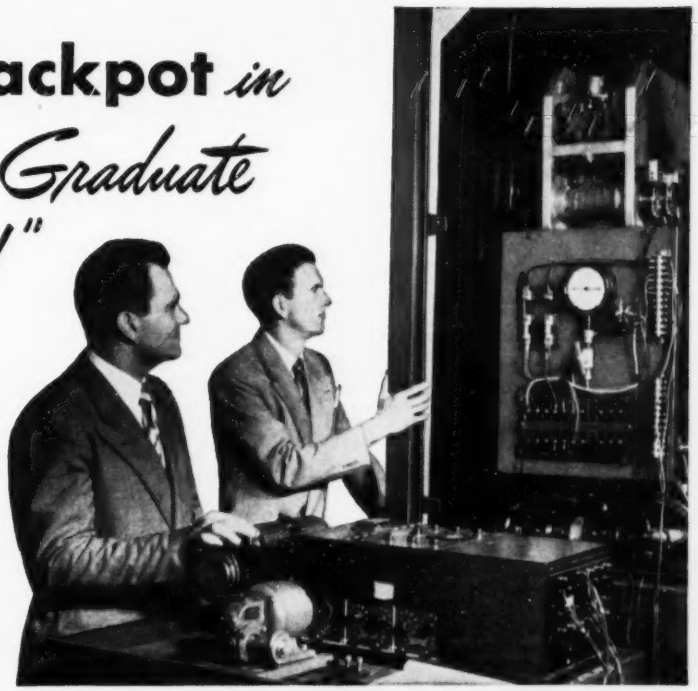
**5701 West Imperial Highway Los Angeles**

**12214 South Lakewood Blvd. Downey, Calif.**

**North American Aviation, Inc. Columbus 6, Ohio**

*organization, facilities and experience keep* **North American Aviation** *years ahead in aircraft . . . guided missiles . . . electronics . . . atomic energy . . . research and development*

# "We Hit the Jackpot *in* *Allis-Chalmers Graduate Training Course!*"



**say N. W. MORELLI**

*Oregon State College, B.S.,M.E.—1950*

**and**

**E. R. PERRY**

*Texas A. & M., B.S.,E.E.—1950*

WHILE taking the course, two engineers developed a revolutionary new circuit breaker mechanism.

"Our experience shows what *can* happen if you work with people open to suggestion. We found men of this kind at Allis-Chalmers, and it has given us a special pleasure in our job.

"We started out like most other graduates with a hazy idea of what we wanted to do. After working in several departments, we requested that part of our training be at the Boston Works of Allis-Chalmers, where circuit breakers are made."

### New Design Principle

"Circuit breakers soon became an obsession with us, and we got the idea of designing a hydraulic operator and triggering mechanism for these breakers. Most operators for big breakers are pneumatic.

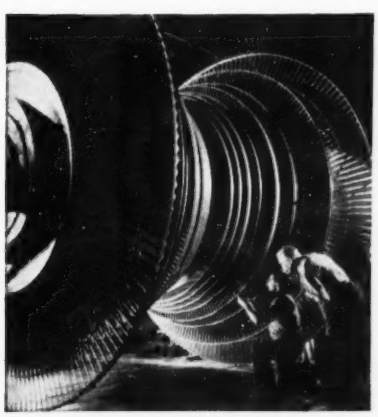
"Unsuccessful attempts had been made in the past by all circuit breaker manufacturers to build hydraulic operators. The important thing is that no one at Allis-Chalmers said, 'Don't try it—it won't work.' "

### Start New Era

"To make a long story short, our study of the problem led us to the hydraulic accumulator and high speed valves being used by the aircraft industry. These had not been available when earlier attempts were made to build a hydraulic operator. With these highly developed devices to work with, we were able to build an operator that combined the best features of pneumatic and hydraulic operation. We call it the *Pneu-draulic* operator. Engineers are saying it starts a new era in circuit breaker actuation.

"This fact is important to us, but it is even more important to know that Allis-Chalmers Graduate Training Course is full of opportunity . . . and as we found out, there's opportunity right from the start."

*Pneu-draulic* is an Allis-Chalmers Trademark.



**Low-pressure spindle** for a 120,000 kw steam turbine generator. Said to be one of the largest ever built in the United States, this spindle is nearing completion in the Allis-Chalmers West Allis shops.

### Facts You Should Know About the Allis-Chalmers Graduate Training Course

**1.** It's well established, having been started in 1904. A large percentage of the management group are graduates of the course.

**2.** The course offers a maximum of 24 months' training.

**3.** The graduate engineer may choose the kind of work he wants to do: design, engineering, research, production, sales, erection, service, etc.

**4.** He may choose the kind of power, processing, or specialized equipment with which he will work, such as: steam or hydraulic turbo-generators, circuit breakers, unit substations, transformers, motors, control, pumps, kilns, coolers, rod and ball mills, crushers, vibrating screens, rectifiers, induction and dielectric heaters, grain mills, sifters, etc.

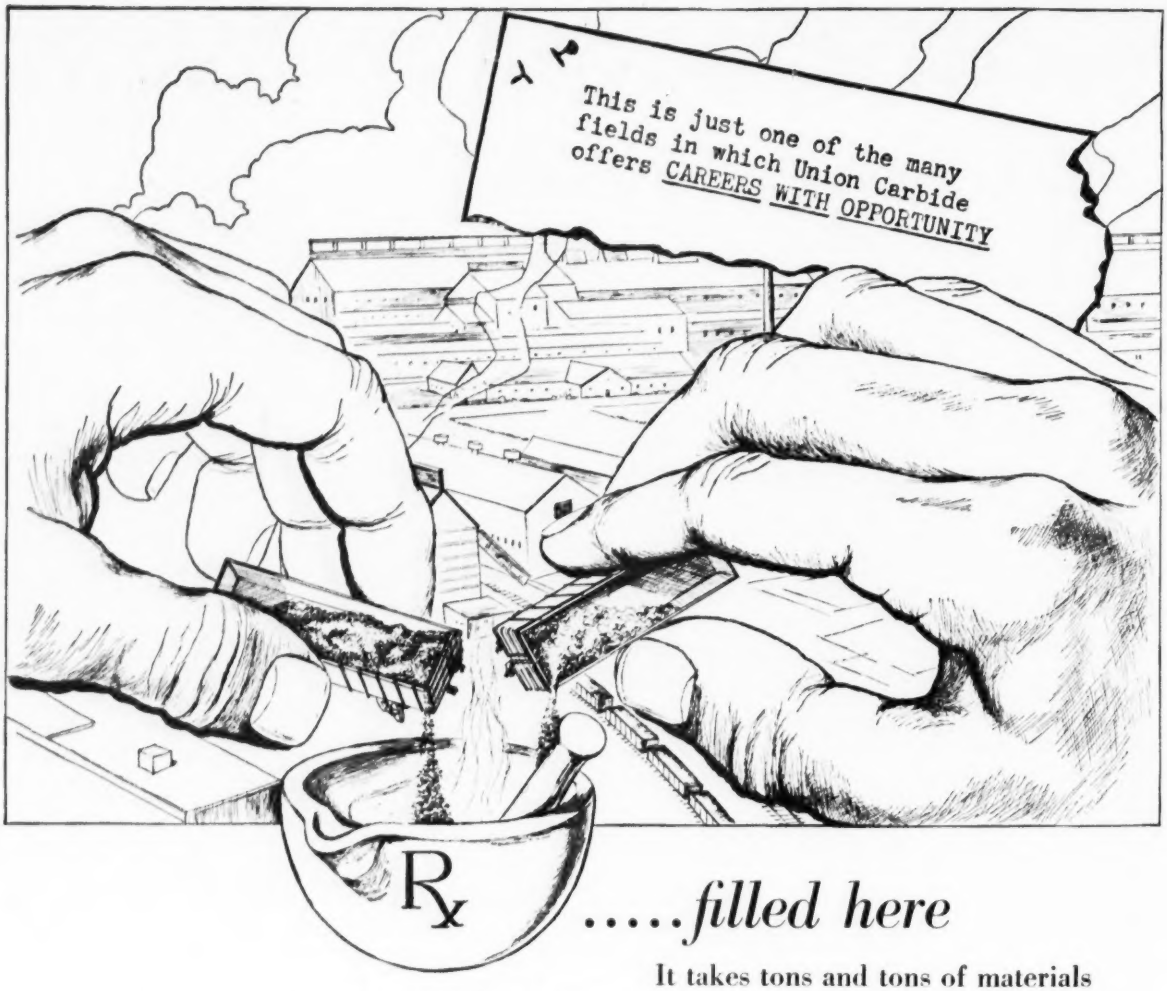
**5.** He will have individual attention and guidance in working out his training program.

**6.** The program has as its objective the right job for the right man. As he gets experience in different training locations he can alter his course of training to match changing interests.

**7.** For information watch for the Allis-Chalmers representative visiting your campus, or call an Allis-Chalmers district office, or write Graduate Training Section, Allis-Chalmers, Milwaukee 1, Wisconsin.

**ALLIS-CHALMERS**

C-5675




# Rx .....*filled here*

**It takes tons and tons of materials to fill the prescriptions that give strength and stamina to the steel you use**

THE STEEL that's everywhere—in your automobile, in trains, machines, and buildings—is stronger and more enduring because it has been treated with special "vitamins and tonics."

**STEEL GETS ITS VITAMINS** from the industry's "drugstores"—the plants where alloying metals are made. Here, prescriptions usually call for ingredients by the ton. Their huge "mixing bowls" are white-hot electric arc furnaces, in which temperatures reach over 3,500 degrees Fahrenheit.

These alloying metals are refined and concentrated forms of both rare and common metals. Among them are chromium, boron, silicon, tungsten, columbium, and vanadium. Individually, or together, they give steel durability, toughness, hardness, rust and corrosion resistance, and other special qualities. Chromium, for example, is the secret of making steel stainless.

**VARYING COMBINATIONS** of these and other alloys are added to every ton of molten steel produced today. Without them we wouldn't have the hundreds of different kinds of steel that do so much for all of us in so many ways.

**MORE THAN 50 ALLOYS**—The people of Union Carbide pioneered in the development and production of alloying metals. They produce more than 50 different alloys for steel and other metals that go into products that serve you.

**STUDENTS AND STUDENT ADVISERS:** *Learn more about career opportunities with Union Carbide in* ALLOYS, CARBONS, CHEMICALS, GASES, *and* PLASTICS. *Write for booklet K-2.*

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*UCC's Trade-marked Products include*

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*Brig. General David Sarnoff, Chairman of the Board, Radio Corporation of America*

# Sees No. 1 wish come true!

**Television Tape Recording by RCA Opens New Era of Electronic Photography**

In 1956, RCA's General Sarnoff will celebrate his 50th year in the field of radio. Looking ahead to that occasion, three years ago, he asked his family of scientists and researchers for three gifts to mark that anniversary: (1) A television tape recorder, (2) An electronic air conditioner, (3) A true amplifier of light.

Gift No. 1—the video tape recorder—has already been successfully demonstrated, two years ahead of time! Both color and black-and-white TV pictures were instantly recorded without any photographic development or processing.

You can imagine the future importance of this development to television broadcasting, to motion pictures, education, industry and national defense. And you can see its entertainment value to you, in your own home. There the tape equipment could be used for home movies, and—by connecting it to your television set—you could make personal recordings of your favorite TV programs.

Expressing his gratitude for this "gift," Gen. Sarnoff said it was only a matter of time, perhaps two years, before the finishing touches would bring this recording system to commercial reality. He described it as the first major step into an era of "electronic photography."

Such achievements as this, stemming from continuous pioneering in research and engineering, make "RCA" an emblem of quality, dependability and progress.

**INTRIGUING OPPORTUNITIES FOR GRADUATING ENGINEERS**

You're sure to find the exact type of challenge *you* want in Engineering Development, Design, or Manufacturing at RCA. Men with Bachelor's, Master's or Doctor's degrees in EE, ME, IE or Physics are needed. *You'll find your optimum career work* among the hundreds of products RCA produces for the home, science, industry and Government.

If you have the necessary education and experience, you will be considered for a direct engineering assignment. Otherwise, you'll participate in our Specialized Training Program, in which you can explore RCA's many interesting engineering operations for a full year.

Your rapid professional advancement is enhanced at RCA by the free flow of engineering information.

***Write today to: College Relations, RCA Victor, Camden, New Jersey. Or, see your Placement Director.***

*RADIO CORPORATION OF AMERICA*

*World leader in radio—first in television*

# STRESS and STRAIN...

Father (looking cautiously into the living room of a fraternity house): "Does Mort Thompson live here?"

Voice from inside: "Yeah, just bring him in and lay him on the couch."

* * *

Sing a song of sulfides,
A beaker full of lime,
Four and twenty test tubes,
Breaking all the time.
When the cork is taken out,
The fumes begin to reek.
Now isn't that an awful mess
To have six hours a week?

* * *

*Transfer student to fellow boarder: Where do you take a bath?*

*M.E.: In the spring.*

*Student: I said where, not when!*

* * *

"It's not the work I enjoy," said the cab driver, "it's the people I run into."

* * *

**The little tot was sitting demurely on the couch, watching her mother smoking a cigarette. Her nose was wrinkled, and in her pale blue eyes was an expression of child disillusionment. Finally, unable to stand it any longer, she blurted out in her quivering voice, "Mother, when are you going to learn to inhale?"**

* * *

*In a cistern little Willie*
*Threw his little sister Lily.*
*Mother couldn't find her daughter;*
*Now we sterilize our water.*

* * *

A draft board doctor, examing a recruit, commanded: "Read that chart."

"What chart?" asked the draftee.

"That's right," said the doctor, "There is no chart; you're in, boy."

* * *

*The honeymoon is over when she wants a heater in the coupe to keep her warm.*

**One of the married grad students went out with the boys at his fraternity one night. Before he realized it, the next day had dawned. He hesitated to call his wife, but finally hit upon an idea. "I'm back," he shouted over the phone, "Don't pay the ransom!"**

* * *

HISTORY OF A JOKE

1 minute—Freshman thinks of a joke and tells it one night to his girl friend on the steps of Balch Hall.

1 day—Joke circulates through girl friend's sorority and is accidentally overheard by senior in engineering.

1 week—Engineer sends joke to ENGINEER (this is a joke itself) claiming originality. Editor of ENGINEER happens desperately to need five more lines of copy, takes a chance on getting expelled from school by using it.

1 month—Joke appears in back part of magazine among ads. The Dean sees joke and chastises Editor.

1 year—Joke circulates through every engineering college magazine from Louisiana to Minnesota, New York to California.

2 years—Gag writer for a radio program finds local college magazine on a bus and sees joke therein. Joke is heard on next week's program. Gag writer loses union card.

3 years—Reader's Digest prints joke from radio program.

4 years—College professor finally gets around to reading the issue of Reader's Digest and laughs heartily at joke.

5 to 30 years—College professor uses joke to begin first lecture at start of each term.

35 years—Joke passes on to a well-deserved rest together with college professor.

* * *

**Applicant: "I'm Gladys Zell."**

**Personnel Manager: "I'm happy myself. Have a seat."**

Once upon a time a freshman Ag. student sat up all night wondering where the sun went when it went down. And then it dawned on him.

* * *

**Two Cornell M.E.'s were on their way home for vacation on a very cold day. They were riding a motorcycle, and the fellow in back was freezing so, when they stopped for gas, he took off his coat and put it on backwards, buttoning it up to keep out more wind. Soon after they started off again they ran smack into a telegraph pole.**

**The policeman who called in about the accident reported the following to the police chief: "The man riding in front was killed instantly. The man who was riding in back was still alive when we got there, but he died when we straightened out his neck."**

* * *

*"Shall we boil this guy?" said one cannibal to the other as he trussed up the clergyman. "No, he's a friar," said the other.*

* * *

Imagine the newspaper boy's embarrassment when he opened the wrong door in the depot waiting room and yelled "Extra paper."

* * *

**I once had a classmate named Jessar**
**Whose knowledge grew lesser and lesser**
**It at last grew so small—**
**He knew nothing at all—**
**And now he's an Arts professor.**

* * *

*Tourist Guide: "We are passing the largest brewery in the United States."*

*C.E.: "Why?"*

* * *

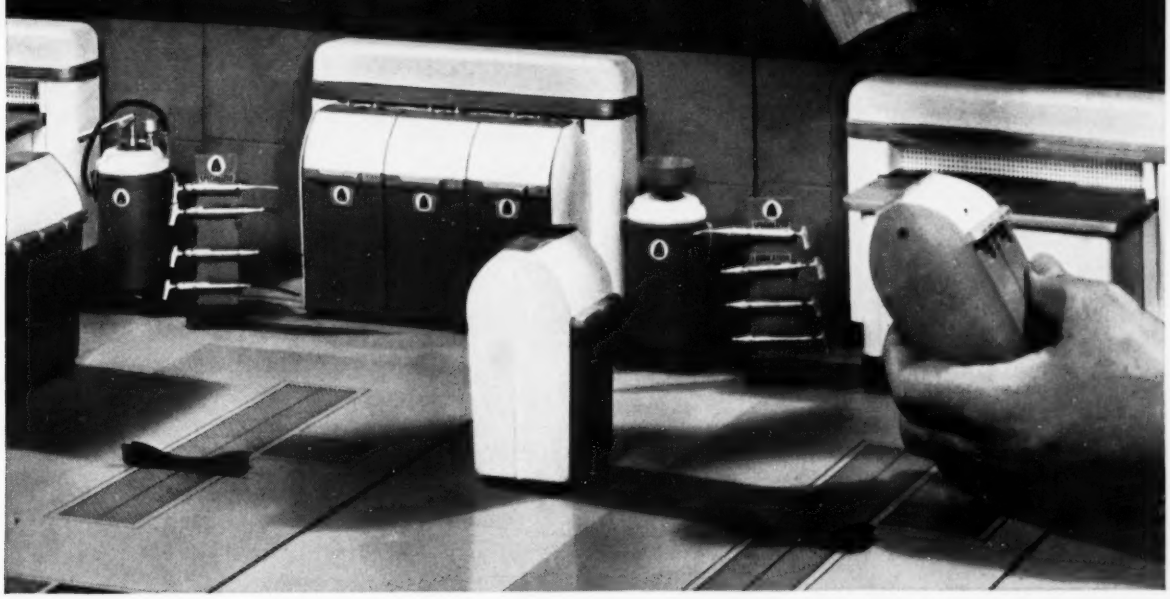
The professor who comes in 15 minutes late is rather rare; in fact, he is in a class by himself.

PHOTOGRAPHY AT WORK—No. 8 in a Kodak Series

Kodak

# Photography shows prospects

## how their new service stations are going to look and operate



**Alemite sets up scale models of their service station equipment on the customer's own floor plan—photographs them—and portrays the new custom-built station ready for action**

SALESMEN don't just pull lube racks, grease pumps and other service station equipment out of a sample case. They're far too big—far too bulky. Besides, final location and arrangement count heavily in how well they are going to work out.

The Alemite Division of Stewart-Warner solves the problem with photography. Prospects see new service station equipment virtually right in their own premises.

**It works this way.** The salesman sends in a rough sketch of the space available, with windows and columns marked. Experts fit exact replicas of racks, lifts, and other equipment to the plan, then put the camera to work. The customer pictures his new station—modern, efficient, handsome—and the sale is well on its way. It's an idea for any company with bulky products to sell. Photography is a great salesman for any business, large or small. And it's very much more. It works in all kinds of ways to save time, cut costs, reduce error and improve production.

**Graduates** in the physical sciences and in engineering find photography an increasingly valuable tool in their new occupations. Its expanding use has also created many challenging opportunities at Kodak, especially in the development of large-scale chemical processes and the design of complex precision mechanical-electronic equipment. Whether you are a recent graduate or a qualified returning service man, if you are interested in these opportunities, write to Business & Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N.Y.

**Eastman Kodak Company, Rochester 4, N.Y.**

# 10 GENERAL ELECTRIC PROGRAMS FOR COLLEGE GRADUATES

Career opportunities with a bright future await the college graduate who joins General Electric. To help him toward early success, G.E. offers these ten programs—each including both challenging work assignments and broadening classroom studies.

If you are interested in building a career with General Electric, consult your placement officer for the date of the next visit of the G-E representative on your campus. Meanwhile, for further information on the career programs described here, write: College Editor, Dept. 2-123, General Electric Co., Schenectady, N. Y.

### ENGINEERING PROGRAM

This program gives engineers a sound foundation for professional careers—in research, development, design, manufacturing, application, sales, installation and service, or advertising.

### APPARATUS SALES ENGINEERING

Offered to men who have completed the Engineering Program, this program develops young men who can combine engineering knowledge with sales contact to sell G-E industrial products.

### MANUFACTURING TRAINING

Open to technical and some non-technical graduates, this three-year program provides leadership training in manufacturing supervision, manufacturing engineering, purchasing, production control, or plant engineering.

### BUSINESS TRAINING COURSE

BTC's purpose is to develop business administration, economics, liberal arts, and other graduates in accounting and related studies for leadership in G.E.'s financial activities and other activities which require business training.

### PHYSICS PROGRAM

For Bachelor and Master graduates, this program gives industrial training and orientation in many fields of physics at G.E.—and offers great diversity in placement openings.

### MARKETING TRAINING

Open to MBA graduates, and to young men who have shown special ability in marketing, this program develops men for future managerial positions through training in all seven primary functions of marketing.

### CHEMICAL AND METALLURGICAL PROGRAM

Open to chemists, metallurgists, chemical, ceramic, and metallurgical engineers at BS and MS level. Assignments extend from process development to plant liaison from research and development to sale of process instruments.

### EMPLOYEE & PLANT COMMUNITY RELATIONS TRAINING

Open to technical and non-technical graduates, this leadership training program provides assignments in engineering, manufacturing, marketing, finance, and employee and plant community relations.

### ATOMIC "TEST"

Open to science and engineering graduates, this program is conducted in the Hanford Atomic Products Operation at Richland, Washington to train men for positions in the atomic energy field.

### ADVERTISING TRAINING COURSE

This program combines on-the-job training with integrated classwork courses and offers the opportunity to learn all aspects of industrial advertising, sales promotion, and public relations.

GENERAL ELECTRIC